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Detailed Development Plan, USBM Pilot Demonstration Oil Shale Mine, Piceance Creek Basin, Rio Blanco County, Colorado

Prepared For

United States Department of the Interior
Bureau of Mines

By

Cameron Engineers, Inc.
1315 South Clarkson Street
Denver, Colorado 80210

Report
On
SO241074: A Technical and Economic Study of Candidate Underground Mining Systems for Deep, Thick Oil Shale Deposits

March 15, 1976

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DETAILED DEVELOPMENT PLAN,
USBM PILOT DEMONSTRATION OIL SHALE MINE,
PICEANCE CREEK BASIN, RIO BLANCO COUNTY, COLORADO

Prepared for

UNITED STATES DEPARTMENT OF THE INTERIOR
BUREAU OF MINES

By

CAMERON ENGINEERS, INC.
1315 South Clarkson Street
Denver, Colorado 80210

REPORT
ON
S0241074: A Technical and Economic Study of Candidate Underground Mining Systems for Deep, Thick Oil Shale Deposits

March 15, 1976

FOREWORD

This report was prepared by Cameron Engineers, Inc., 1315 South Clarkson Street, Denver, Colorado under U.S. Bureau of Mines Contract Number S0241074. The contract was initiated under the Bureau of Mines Program for Advancing Mining Technology - Oil Shale. It was administered under the technical direction of Denver Mining Research Center.

This report is a summary of the work recently completed as a modification to the original contract during the period January to March 1976 and submitted by the authors on March 15, 1976.

As part of their Energy Research and Development Program, the U.S. Bureau of Mines plans to develop a pilot mine research facility in the central Piceance Creek basin. The primary purpose of the test mine is to evaluate the potential of mining the deep, thick oil shale deposits by several proposed methods. These methods include chamber and pillar mining, full extraction sublevel stoping, sublevel stoping with backfilling, and block caving using LHD transport. In addition, research programs will be conducted to further evaluate equipment technology, ventilation systems, spent shale backfilling, novel mining concepts, in situ stresses, rock physical properties, and the response of the rock mass to excavation.

The proposed site selected for the research facility is located on Bureau of Land Management (BLM) land and falls under that agency's jurisdiction. Prior to the development and construction of the pilot mine, the BLM must prepare an Environmental Assessment Report (EAR) on the project. As a prerequisite to the required EAR the Bureau of Mines must submit a development plan to the BLM. This report comprises the development plan of the Bureau of Mines for submittal to the BLM.

ACKNOWLEDGEMENTS

This report was prepared between Janaury 15 and March 15, 1976 under the direction of the following Bureau of Mines, Denver Mining Research Center personnel:

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Robert L. Bolmer - Mining Engineer
James E. Hawkins - Geologist
John R. Widows - Mining Engineer

The principal investigators and consultants listed below are also recognized for their assistance in the completion of this project.

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SUMMARY

This report is a Detailed Development Plan for a proposed demonstration mine to be built and operated by the Bureau of Mines under a letter agreement with the BLM. The proposed site is located in R97W, T1S, T2S, Rio Blanco county, Colorado and includes 2,320 acres of land for surface and mining use with an additional 320 acres for surface use only.

The primary purpose of the proposed pilot demonstration mine will be to determine the technical and economic feasibility of mining the deep, thick oil shale deposits that are represented in the proposed site. As a secondary purpose, the proposed mine will also evaluate possible health and safety hazards, environmental impacts, rock mechanics, ventilation, and hydrological problems, equipment performance, transportation systems, novel mining systems, and provide bulk samples for metallurgical testing. ?

The mine will be developed in five phases which will include the following:

- A core drilling and geophysical data collection program.
- Boring an 8-foot inside diameter shaft to provide bulk metallurgical samples, preliminary rock mechanics data, ventilation, and emergency escapeway.
- Sinking a 20-foot inside diameter main access shaft.
- Site preparation.
- Surface facilities construction.
- Mine development.
- Mining systems testing.
- Abandonment of facility upon completion of research.

Mining systems to be evaluated will include chamber and pillar, sublevel stoping with spent shale backfill, sublevel stoping with full subsidence, and block caving using LHD's. Other novel systems will be tested along with pertinent research programs.

The total estimated time for completion of research and testing is nine years unless additional experimentation becomes necessary. Total development time is estimated to be four years and includes site preparation, shaft boring, bulk sample collection, main shaft sinking, and mine development. Peak manpower is estimated to be 114 during the mining systems testing.

Included in this development plan is a summary of the proposed activities, project area description, mine plan, and summaries of sociocultural actions, ? project mitigating actions, and reclamation and abandonment plans.

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1.0 INTRODUCTION

The Piceance Creek basin in northwestern Colorado contains the world's largest single reserve of oil shale. An estimated 600 billion barrels of oil equivalent are contained in kerogenaceous marlstones averaging at least 25 gallons of oil per ton (gpt). The central portion of the basin contains the thickest and richest deposits which average approximately 2,000 feet in thickness, and may be under as much as 1,600 feet of overburden. These deposits also contain significant quantities of alumina (dawsonite) and soda ash (nacholite) that are expected to play an important role in the overall economics.

To date, virtually all research and testing of oil shale mining techniques has been limited to underground room-and-pillar methods in the relatively thin and shallow deposits exposed around the edge of the basin. However, nearly 80 percent of the oil shale, and virtually all the associated sodium and alumina minerals, are confined to the much thicker and deeper deposits in the central part of the basin. No proven methods exist for mining these deposits, which are expected to present major problems in shaft and mine design, groundwater control, and subsidence.

New mining methods, or modifications of existing methods must be developed for the high production, low cost mining operations envisioned for the central portion of the basin. In order to determine the best way of developing and mining these deposits over a wide range of conditions, the Bureau of Mines is studying underground mining techniques. Four are currently being considered for field demonstration. These methods are chamber and pillar, sublevel stoping with full subsidence, sublevel stoping with spent shale backfill, and block caving using load-haul-dump (LHD) machines.

1.1 PURPOSE

The purpose of this prototype demonstration mine will be to develop new technology, verify technical and economic feasibility, evaluate inherent safety, and determine the environmental effects of the most promising mining methods. In addition, technical information on the character of deep oil shale deposits will result from proposed allied research studies.

Special Projects Branch
Bill Quinlenfeld
John Egi
?

The Bureau of Mines, with the help of the Geological Survey, has selected a site for the proposed prototype demonstration mine in the central part of the Piceance Creek basin. Since the facility is intended to generate information for mining deep, thick, oil shale sequences, efforts were made to select a site that will be representative of deposits in this basin. The following guidelines were used in selecting the site:

1. General site area to include 2,000 to 5,000 acres of contiguous public lands.
2. About 800 to 1,000 feet of overburden above the Mahogany zone.
3. Not more than 400 feet of water-bearing, saline-leached oil shale below the Mahogany zone.
4. Approximately 500 to 1,000 feet of unleached saline oil shale above the Blue Marker, averaging about 20 gpt and containing representative amounts of nahcolite and dawsonite but minimum amounts of halite.
5. Representative ground water conditions for the central part of the basin.
6. Absence of major fault or fracture systems.

The selected site is on public land administered by the Bureau of Land Management. After studying development plans and environmental protection/mitigation measures, an interagency agreement between the Bureau of Mines and the Bureau of Land Management will be proposed to set aside and reserve the selected site.

1.2 CONTENT

This Detailed Development Plan for the Bureau of Mines prototype mine facility includes discussions on the proposed activities of the pilot mine facility, the regional and local description of the project area, and a detailed mine plan. The sociocultural actions, a summary of project mitigating actions, and the reclamation and abandonment plans conclude the report.

2.0 SUMMARY OF PROPOSED ACTIVITIES

The construction and operation of the pilot demonstration mine will necessarily result in certain activities that directly or indirectly relate to the local environment and communities. This section describes in summary form, the actions that will occur during the development and operation of the facility.

2.1 SITE ACCESS

The proposed pilot demonstration mine site is located in R97W, T1S, Section 30, Rio Blanco County, Colorado. Present access to the proposed site is by County Road 5 which parallels Piceance Creek between the town of Rio Blanco and Colorado Highway 64.

A 30 foot wide, two lane gravel road will be constructed across Piceance Creek from County Road 5, westward up Horse Draw. The road will be constructed to AASHO standards along Horse Draw to minimize cutting and filling. Approximately five culverts will be constructed across various drainage systems to eliminate stream diversions and allow the natural drainage system to remain. The road will be graded and watered as needed for dust control.

The power corridor will parallel the proposed mine site road. An estimated 138,000 kv power line will be run into a 5 to 10,000 kva electric substation located on the proposed site. Two-pole, raptor proof power pole construction will be used to carry three high voltage power lines.

Outside communications will be provided by a two-way radio telephone system tied into a Grand Junction operator.

2.2 DATA COLLECTION

A core drilling program, consisting of one to five core holes, will be used to collect more detailed geological and engineering data for the final mine design. Core hole layout is limited to the specific pilot demonstration mine site.

A geophysical research program will be conducted to obtain additional data on geology and engineering properties. Approximately 35 miles of seismic lines are planned using some of the following methods:

- High resolution seismic
- Shear wave seismic

- Resistivity
- Audio magneto tellurics
- Natural tellurics
- Magnetics

2.3 SHAFT BORING AND BULK SAMPLE COLLECTION

An 8-foot inside diameter shaft will be bored from the surface to a depth of approximately 2,400 feet. A 500-ton bulk sample of dawsonite will be collected from a small excavation in the shaft at an elevation to be determined after more detailed geologic data is obtained. Approximately ten to 15 acres will be required for the drilling site with the boring taking approximately ten months to complete. The finished shaft will be used for the proposed demonstration mine exhaust ventilation and emergency escapeway.

2.4 SITE DEVELOPMENT AND CONSTRUCTION

The proposed surface facilities site is located on a ridge in Horse Draw and will include approximately 10 acres. This area will be cleared and graded prior to the construction of permanent facilities. Permanent facilities will include:

- Office and changehouse.
- Hoisthouse and compressorhouse.
- Headframe.
- Warehouse and repairshop.
- Fuel storage.
- Electric substation.
- Fanhouse.
- Parking lot.
- Supply yard.
- Security hut.

The entire proposed site will be enclosed by a deer and livestock-proof fence. Surface drainage will be into a catchment dam located in an adjacent intermittent stream valley. Facilities will be constructed of prefabricated materials and placed on concrete pads.

Two explosives and cap magazines will be constructed approximately 1,000 feet west of the site and secured by a deer and livestock-proof fence. A

20,000 gallon potable water tank will be constructed above the plant site. Access to both facilities will be by graded dirt roads.

2.5 DAMS AND ORE STOCKPILE

Two earthfill embankments will be constructed in the drainages immediately adjacent and east of the proposed site. The dam nearest the site will be approximately 30 feet high and be used to collect run-off water from the plant site and ore stock pile. A saline water impoundment approximately 50 feet high will be constructed in the next adjacent drainage and be used to store water pumped from the mine and ore stockpile catchment dam.

The ore stockpile will be considered temporary with attempts made to sell the potentially valuable ore. Construction of the stockpile will start at the top of the drainage above the catchment dam and proceed down. Total storage capacity will be approximately 2,000,000 yd^3.

2.6 MAIN ACCESS SHAFT

A 20-foot inside diameter concrete lined shaft will be sunk approximately 2,360 feet and used for intake ventilation, production, and service for the proposed pilot demonstration mine. Two shaft stations will be excavated at levels to be determined after more detailed geologic data is available. A freezing technique of sinking will be used for the first 1,400 feet of shaft, with the remainder sunk conventionally. Temporary support facilities for the shaft will include:

- Office trailer
- Concrete batch plant
- Changehouse
- Freeze plant

Sinking time for the shaft will be approximately 30 months.

2.7 POTABLE WATER WELLS

Three potable water wells will be drilled above the proposed site and will provide water for the mine plant, underground mine, and saline water dilution. These wells will be 12 to 16 inches in diameter and drilled to the base of the "A" groove. Electric motors from 130 to 150-hp will provide a pumping capacity of 600 gpm for each well. Water lines from the wells will be buried.

2.8 WATER TREATMENT

As water is pumped from the mine into the saline water storage dam, it

?

will be tested for water quality. If the water meets minimum standards, it will be released into the Horse Draw drainage. However, if the water is below water quality standards, it will be diluted to the required levels by using fresh water from the potable water wells. Water quality monitoring wells will be located below the proposed pilot demonstration mine site in the Horse Draw drainage to ensure minimum standards are maintained.

2.9 MINING PLAN

Several mining systems will be tested in the proposed pilot demonstration mine. Four of these systems will be chamber and pillar (with spent shale backfill), sublevel stoping with full subsidence, sublevel stoping with spent shale backfill, and block caving using LHD's.

The approximate dimensions of the mine layout will be 2,000 by 2,300 feet and include mining on two levels. The maximum proposed excavated area will be on the upper level in the leached zone and measure approximately 400 feet square. This area will be used to test the cavability of oil shale. The highest openings will occur on the lower mining level and will be no greater than 280 feet.

?

The estimated maximum vertical subsidence will be 1.3 feet and occur above the sublevel stoping with full subsidence test area.

An estimated 2,700,000 tons of ore grade shale will be mined from the four mining system test areas. Mine life, after shaft construction is estimated to be approximately five years. However, if additional research projects are warranted to further evaluate the technical and economic feasibility of underground oil shale mining, the pilot mine life may be extended.

Standby plans, in case operating funds for the facility are reduced, include a caretaking crew to perform necessary inspection and maintenance.

2.10 RESEARCH PROJECTS

Several research projects are planned for the proposed pilot demonstration mine to evaluate the effects of mining deep, thick oil shale deposits. These projects will include:

- Rock mechanics studies
- Ventilation studies
- Blasting studies

- Stope backfilling
- Equipment design and evaluation
- Other mining concepts

The only research study that will include work performed on the surface is subsidence monitoring. A comprehensive survey net will be used to measure predicted vertical and horizontal surface movements due to underground excavations. This survey net will use small pipes, one inch in diameter, set in approximately one cubic foot of concrete, as front sight stations. Once the net is completed, no access to the monuments will be necessary.

The remainder of the research project will take place underground and have no surface effects.

2.11 ABANDONMENT AND REVEGETATION

The total time proposed for the pilot demonstration mine will be approximately nine years if the project life is not extended or the mine leased by the Department of Interior. Abandonment procedures for the pilot mine at the time of decommissioning are outlined below:

- Surface plant facilities - all salable items will be dismantled and removed.
- Concrete building foundations will be broken up and graded to the approximate original ground contours.
- Hard surfaced roads will be broken up in place and graded.
- Underground pipes and culverts will be broken up or left in place and plugged.
- Embankments will be leveled, filled with earth, or turned over to government or local wildlife organizations.
- Ore left in the stockpile will be covered with topsoil and revegetated.
- All knocked down areas and the plant site will be covered with topsoil and revegetated.
- Sidehill cuts and benches will be filled or smoothed.
- Mine shafts will be filled and plugged.
- All secondary roads will be graded to remove drainage structures and revegetated.
- Revegetated areas will be monitored and maintained until proper growth is ensured.
- core holes & wells ?

2.12 MITIGATING ACTIONS

Throughout the development and research testing operations of the proposed pilot demonstration mine, mitigating actions will be made to

reduce environmental impact. Some of these actions are listed below:

- Roads will be graded and watered as needed to reduce erosion and dust contamination.
- Power lines will be raptor proof.
- Culverts will be built over drainages so that drainage systems will not be disturbed.
- Employees will be urged to use car pools. Bus transportation will be evaluated in an attempt to reduce road traffic.
- All drill sites will be reclaimed as necessary.
- The 8-foot and 20-foot inside diameter shafts will use as much of the same site as possible. All distrubed areas not used for the permanent surface facilities will be reclaimed.
- All above ground structures will be painted a color that will blend with the environment.
- Only biodegradable soaps will be used in the shower facilities with the waste water diverted into the ore stockpile catchment dam.
- Impermeable safety berms will be constructed around the fuel storage tanks.
- Surface runoff from the proposed site will be directed into the ore stockpile catchment dam and tested prior to discharge into Horse Draw.
- Water pumped from the mine will be stored in the saline water impoundment area and tested prior to discharge. If necessary the water will be diluted with fresh water.
- The compressor house and fan house will be sound-proofed as much as possible.
- Waste rock not used in embankment construction will be disposed of on the bottom of the ore stockpile.
- Water monitoring wells will be installed in the lower Horse Draw drainage to ensure water quality standards are met.
- Runoff water through the ore stockpile will be caught behind a catchment dam and tested prior to release. If the water is below standards, it will be pumped to the saline water storage impoundment and diluted before release.
- Water storage dams are located below the elevation of the mine site to eliminate personnel hazards in case of failure.
- The downstream faces of the dams will be revegetated.
- Water level & analysis ?

2.13 SOCIOCULTURAL ACTIONS

The estimated maximum number of employees staffing the proposed facility

will be 114. The lowest number of employees will be four. Whenever possible, employees will be hired from local areas. It is expected that a small number of skilled personnel will be attracted to the area to fill certain jobs. In the absence of such skilled personnel, job training will be offered.

Industry/community communication will help communities plan for industry associated growth. At the present time, adequate housing for incoming workers probably exists in Rangely and Rifle. Private plans are being made for construction of mobile home spaces in Meeker, Rifle, and Grand Valley.

Private plans for increasing sewage and water capacity in Rangely and Meeker are being made. Once these changes are complete, systems will be adequate to support a small population influx.

The economic benefits to the surrounding towns will be lessened when the proposed mine discontinues operation.

incomplete!

3.0 PROJECT AREA DESCRIPTION

These descriptions of the Piceance Creek basin and proposed pilot mine site are intended to provide continuity to the report and have been modified from available literature. Additional baseline data has not been added.

3.1 REGIONAL DESCRIPTION, PICEANCE CREEK BASIN

3.1.1 Physiography

The Piceance Creek basin is a major structural basin in Rio Blanco, Garfield, and Mesa counties, Colorado, Figure 3.1. The basin is bounded by steep escarpments that face the Colorado River on the south, the White River on the north, the valleys of Government and Sheep creeks on the east, and Douglas Creek on the west.

The Roan Plateau, an east-west trending structure in the southern part of the basin, forms a drainage divide between tributaries of the Colorado River to the south and the White River to the north. The northern drainage system is the larger of the two, and the principal streams in this drainage are Piceance Creek and Yellow Creek. Principal streams in the southern drainage system are Parachute Creek and Roan Creek.

Differential resistance to erosion has produced parallel, northeasterly oriented bedrock ridges with local relief of 200 to 600 feet.

3.1.2 Climate

Annual precipitation in the semi-arid Piceance Creek basin varies from approximately 12 inches in the extreme northwest to approximately 24 inches in the southwest. Slightly less than half of the precipitation occurs as snow from December to April, and spring precipitation is usually very low. During the latter part of the summer, occasional thunderstorms, with accompanying flash floods, may occur throughout the area. Fair weather and infrequent rain or snowstorms characterize fall weather.

The area is subject to thermal extremes; summer temperatures may reach 100 degrees and winter temperatures may drop to 40 degrees below zero Fahrenheit. The frost-free season varies from 124 days at the lower elevations to

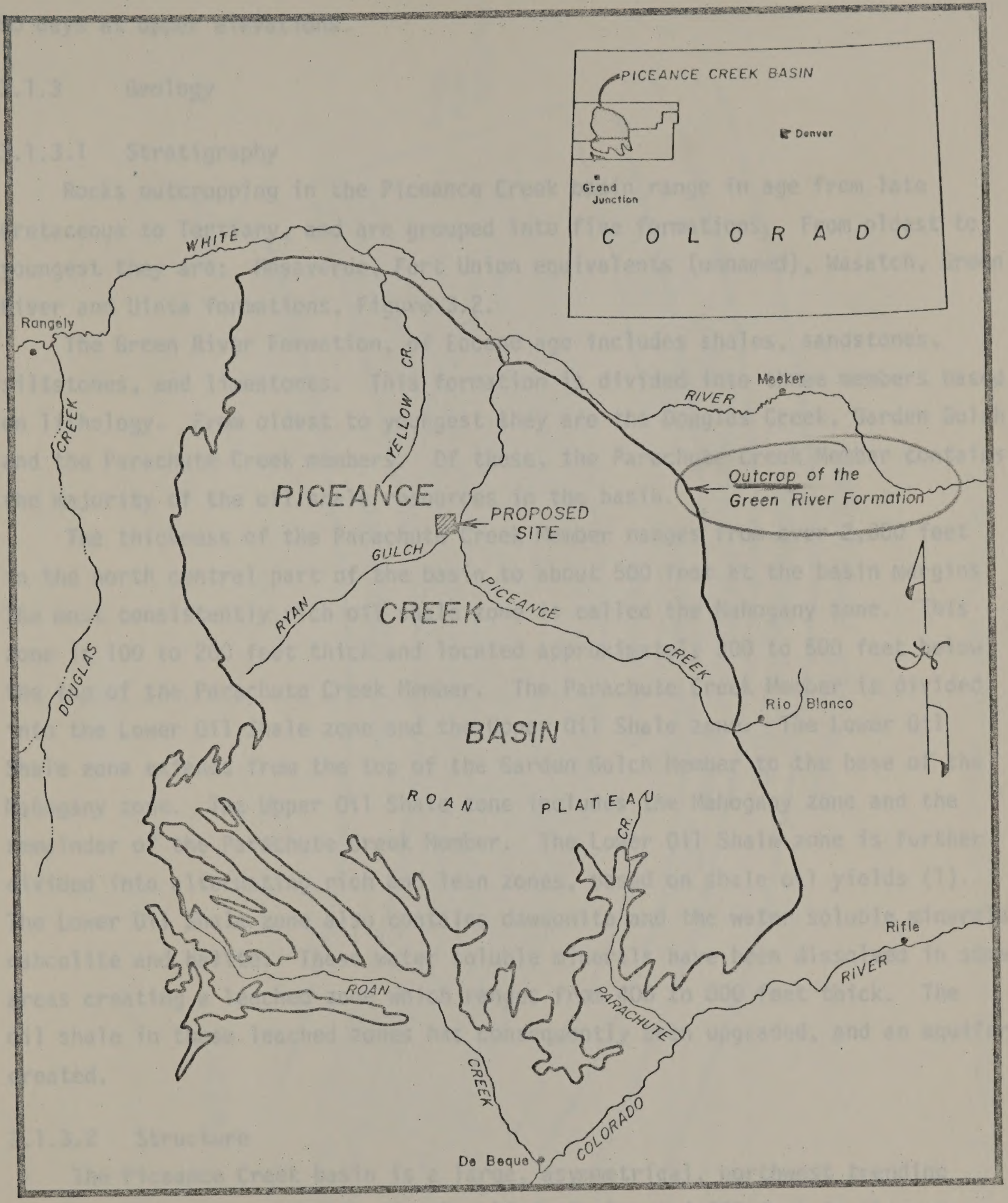


Figure 3.1 Location of Piceance Creek Basin

50 days at upper elevations.

3.1.3 Geology

3.1.3.1 Stratigraphy

Rocks outcropping in the Piceance Creek basin range in age from late Cretaceous to Tertiary, and are grouped into five formations. From oldest to youngest they are: Mesaverde, Fort Union equivalents (unnamed), Wasatch, Green River and Uinta formations, Figure 3.2.

The Green River Formation, of Eocene age includes shales, sandstones, siltstones, and limestones. This formation is divided into three members based on lithology. From oldest to youngest they are the Douglas Creek, Garden Gulch and the Parachute Creek members. Of these, the Parachute Creek Member contains the majority of the oil shale resources in the basin.

The thickness of the Parachute Creek Member ranges from over 2,000 feet in the north central part of the basin to about 500 feet at the basin margins. The most consistently rich oil shale zone is called the Mahogany zone. This zone is 100 to 200 feet thick and located approximately 300 to 500 feet below the top of the Parachute Creek Member. The Parachute Creek Member is divided into the Lower Oil Shale zone and the Upper Oil Shale zone. The Lower Oil Shale zone extends from the top of the Garden Gulch Member to the base of the Mahogany zone. The Upper Oil Shale zone includes the Mahogany zone and the remainder of the Parachute Creek Member. The Lower Oil Shale zone is further divided into alternating rich and lean zones, based on shale oil yields (1). The Lower Oil Shale zone also contains dawsonite and the water soluble minerals nahcolite and halite. These water soluble minerals have been dissolved in some areas creating a leached zone which ranges from 400 to 800 feet thick. The oil shale in these leached zones has consequently been upgraded, and an aquifer created.

3.1.3.2 Structure

The Piceance Creek basin is a large, asymmetrical, northwest trending structural downwarp with structural relief of almost 4,000 feet in the area north of the Colorado River, Figure 3.3. There are several large substructures:

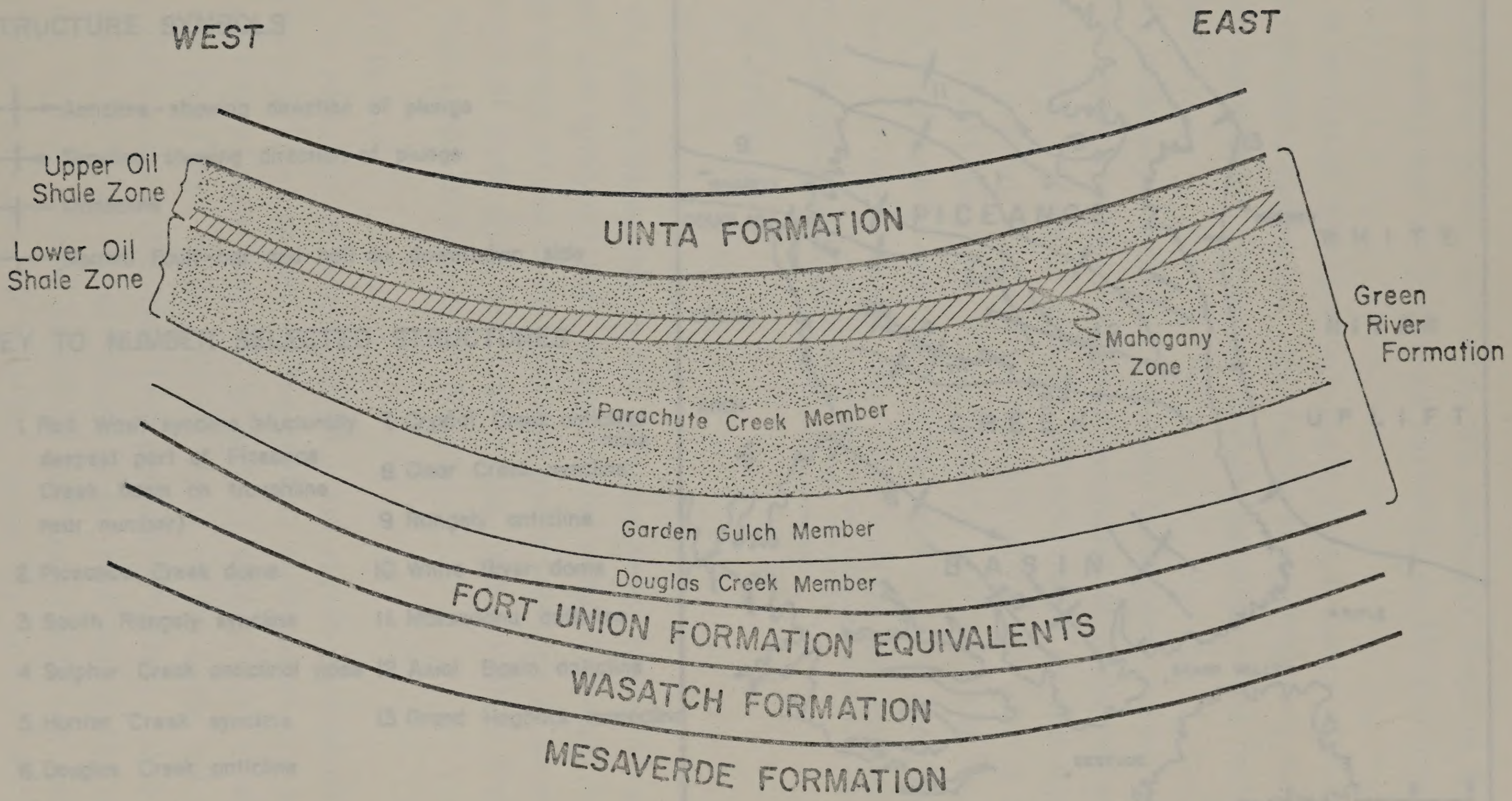


Figure 3.2 Geologic Cross Section Through Piceance Creek Basin

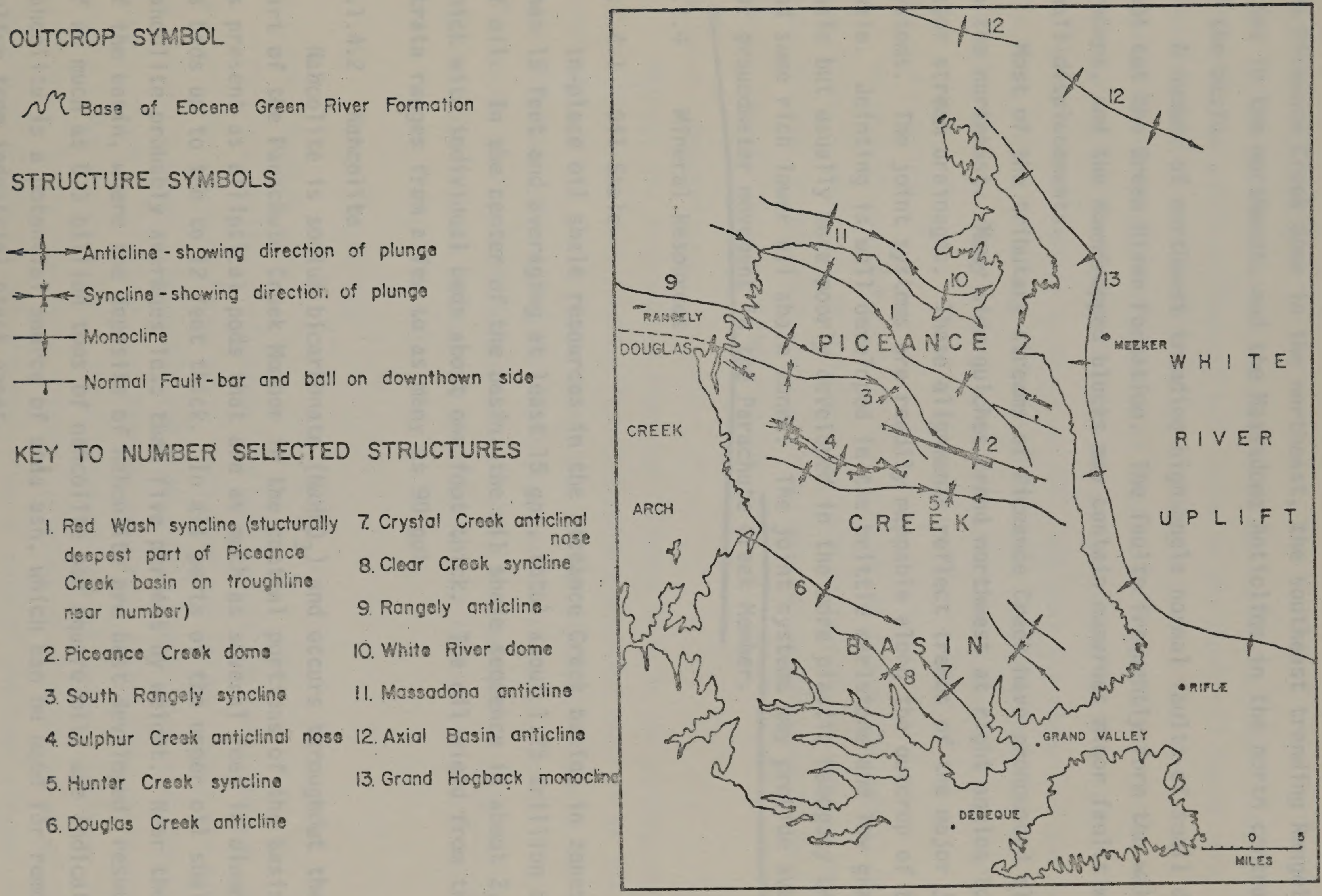

OUTCROP SYMBOL
Base of Eocene Green River Formation
STRUCTURE SYMBOLS
Anticline - showing direction of plunge
Syncline - showing direction of plunge
Monocline
Normal Fault - bar and ball on downthown side
KEY TO NUMBER SELECTED STRUCTURES
1. Red Wash syncline (stucturally deepest part of Piceance Creek basin on troughline near number)
2. Piceance Creek dome
3. South Rangely syncline
4. Sulphur Creek anticlinal nose
5. Hunter Creek syncline
6. Douglas Creek anticline
7. Crystal Creek anticlinal nose
8. Clear Creek syncline
9. Rangely anticline
10. White River dome
11. Massadona anticline
12. Axial Basin anticline
13. Grand Hogback monocline
PICEANCE CREEK BASIN
WHITE RIVER UPLIFT
DOUGLAS CREEK ARCH
RANGELY
MEEKER
RIFLE
GRAND VALLEY
DEBEQUE
5 0 5
MILES

Figure 3.3 Tectonic Map of Piceance Creek Basin (2)

the Piceance Creek dome in the northeast, the southeast trending Rangely anticline in the northwest, and the Massadona Anticline in the north central part of the basin.

A number of northwest trending high-angle normal faults of small displacement cut the Green River Formation. The faults frequently form the walls of grabens, and the downdropped blocks may contain numerous minor faults with small displacements.

Most of the tributary streams of Piceance Creek have pronounced alignments to the northeast. Many side gulches trend northwest at right angles to the major stream drainages. These alignments reflect trends of the major joint systems. The joint systems are readily mappable along the outcrop of the oil shale. Jointing is well developed in the brittle marlstone and low grade oil shale but usually more poorly developed in the more plastic Mahogany Ledge and some rich lower oil shale zones. The joint systems may provide avenues for groundwater movement in the Parachute Creek Member.

3.1.4 Mineral Resources

3.1.4.1 Oil Shale

In-place oil shale resources in the Piceance Creek basin, in zones thicker than 15 feet and averaging at least 15 gpt, total about 1.25 trillion barrels of oil. In the center of the basin, the oil shale sequence is about 2,000 feet thick with individual beds about one foot thick. The oil yield from these strata ranges from a few to as many as 90 gpt.

3.1.4.2 Nahcolite

Nahcolite is sodium bicarbonate ($NaHCO_3$) and occurs throughout the major part of the Parachute Creek Member in the central portions of the basin. It is present as elliptical pods that are as much as several feet in diameter, or as beds up to ten to 12 feet thick. In all parts of the upper oil shale zone, nahcolite probably averages less than five percent by weight. Near the center of the basin, where the deposits of nahcolite are best developed, resources of as much as 0.3 billion tons of nahcolite per square mile are indicated (3). Nahcolite is a potential source of soda ash, which can be used for removal of sulfur from industrial stack gases.

3.1.4.3 Dawsonite

Dawsonite is dihydroxy sodium aluminum carbonate, $(NaAl)(OH)_2(CO_3)$, and is finely disseminated through oil shale in the Lower Oil Shale zone in the central part of the basin. It is relatively easy to extract alumina from dawsonite. Although the percent of alumina in dawsonite is small, in light of recent price increases of bauxite, dawsonite may be of economic interest. A sequence of oil shale as thick as 800 feet near the center of the basin, contains dawsonite in appreciable quantities. Units of minable thickness may contain three to five percent by weight of equivalent extractable alumina.

3.1.4.4 Halite

An area of approximately 75 square miles in the north-central part of the basin is underlain by halite. The zone containing halite may be more than 300 feet thick, with individual halite beds as thick as 30 feet. The halite beds contain no organic matter.

3.1.4.5 Natural Gas

Natural gas is produced from the Piceance Dome in the northeastern part of the Piceance Creek basin. The uppermost productive zone is in the basal sandstone of the Green River Formation. Other productive sandstones as much as 6,000 feet below the Green River Formation are known. In other parts of the basin, gas-bearing sandstones have been encountered in many exploration wells. However, the wells have been capped due to limited production potential.

3.1.5 Water Resources

3.1.5.1 Surface Water

Piceance, Yellow, Parachute, and Roan creeks are the principal streams draining the Piceance Creek basin. Piceance and Yellow creeks are tributary to the White River. Parachute and Roan creeks are tributary to the Colorado River, Figure 3.1. These four streams and their tributaries drain approximately 1,400 square miles. Their combined average annual discharge is 58,000 acre-feet. Water from these streams irrigates about 8,700 acres of farm land. The average discharge and drainage area of each of the four streams is

summarized in Table 3.1.

The primary source of surface water is snowmelt. Secondary sources include rainfall and springs. The surface waters of the upper reaches of the principal streams generally can be classed as a mixed bicarbonate type, grading to a sodium bicarbonate type in the lower reaches.

3.1.5.2 Groundwater

Groundwater occurs throughout the Piceance Creek basin in alluvium and in the Uinta and Green River Formations. The alluvium is generally less than a half mile wide and consists of clay, silt, sand, and gravel.

Aquifers of the Uinta and Green River Formations are divided into the Upper and Lower aquifers. They are separated by the Mahogany zone, which is more plastic than surrounding strata, and less extensively fractured. Existing fractures in the Mahogany zone probably provide avenues of recharge for the Lower aquifer. The Upper aquifer includes siltstones, sandstones and marlstones of the Uinta Formation, and the lean marlstone above the Mahogany zone of the Green River Formation, Figure 3.2. The Lower aquifer is under the Mahogany zone. It consists of fractured marlstone and oil shale of the Parachute Creek Member of the Green River Formation.

Neither the Upper or Lower aquifer has good primary permeability. Bedrock fractures have created the secondary permeability of the Upper aquifer. Lower aquifer transmissivity has been increased by extensive fracturing and leaching of soluble minerals. Nahcolite is the most common soluble mineral and originally may have comprised 20 percent of the Lower aquifer's rock material. The Lower aquifer is underlain by deposits of low transmissivity, with the salts of deposition still in place.

Aquifer test data from 26 wells in the Upper aquifer show that transmissivity ranges from eight to 1,000 ft^2/day, depending upon the extent of fracturing. The contained water is classified sodium bicarbonate type and has moderate concentrations of sulfate. Total dissolved solids ranges from 400 mg/l to more than 2,000 mg/l, increasing in the direction of flow (4).

Transmissivity of the lower aquifer ranges from 1,940 ft^2/day to 2,700 ft^2/day. Twenty-seven water analyses show dissolved solids concentrations ranging from 491 to 38,900 mg/l, the average being 9,400 mg/l (4).

Table 3.1 Average Discharge from Principal Streams Draining the Piceance Creek Basin

Station Location	Drainage Area (mi^2)	Acres Irrigated*	Period of Record (Yrs)	Average cfs	Discharge AF/Yr	Remarks
Piceance Creek at White River	630	5,500	6	21.8	15,790	900 ft. upstream from mouth
Yellow Creek near White River	262	300	1	2.4	1,740	0.3 mile upstream from mouth
Parachute Creek near Grand Valley	151	75	12	19.0	13,770	9 miles north of Grand Valley discontinued 9/70
Roan Creek near DeBeque	321	2,800	15	37.0	26,810	10 miles NW of DeBeque discontinued 9/72
Totals	1,354	8,675		80.2	58,110	

* Acres irrigated above gaging station

Alluvium thickness increases downstream. It is estimated to be up to 140 feet thick, with saturated thicknesses as great as 100 feet. Alluvium transmissivity is variable and depends upon saturated thickness and occurrence of silt and clay-sized material. Transmissivity of the alluvium in the main drainages ranges from 2,700 to 20,000 ft^2/day, with a storage coefficient averaging 0.20 (5). Yields of wells tapping alluvial aquifers are limited by the extent of the aquifer. Water from alluvial aquifers is classified as sodium bicarbonate type. Dissolved solids concentration increases downstream.

3.1.6 Soils

Soils in the Piceance Creek basin range from very thin or none on the steep slopes and cliffs, to thick alluvial soils on the wider valley floors. Upland areas may be covered by thin soils or thick alluvial soil.

Alluvial valley land supports good hay crops where irrigated, otherwise only sagebrush or greasewood. The upland alluvium supports sagebrush with some grass. The thin upland soils generally support pinon-juniper.

Land types such as rock outcrops, rough gullied land, and shale badlands occur as small areas throughout the basin.

3.1.7 Vegetation

Vegetation in the area is predominantly of three major types: sagebrush, mountain shrub, and pinon-juniper. Other vegetation occurring in lesser quantities includes greasewood, saltbush, conifers, broadleaf trees, and grass.

Privately owned valley lands, comprising about five percent of the area, are cultivated and produce mostly hay. No large infestations of poisonous or noxious plants are known in the area.

In recent years large upland areas in the basin have been cleared by dragging a heavy chain between large tractors, with the objective of increasing forage for stock and wildlife, Figure 3.4. Native and special grass seed has been planted in the chained areas. Grass yield in these areas is reported to be several times more than the unchained land. Occasional forest or brush fires in the areas are commonly followed by improved grass stands resulting in improved stock grazing conditions. Grass has been planted in immature

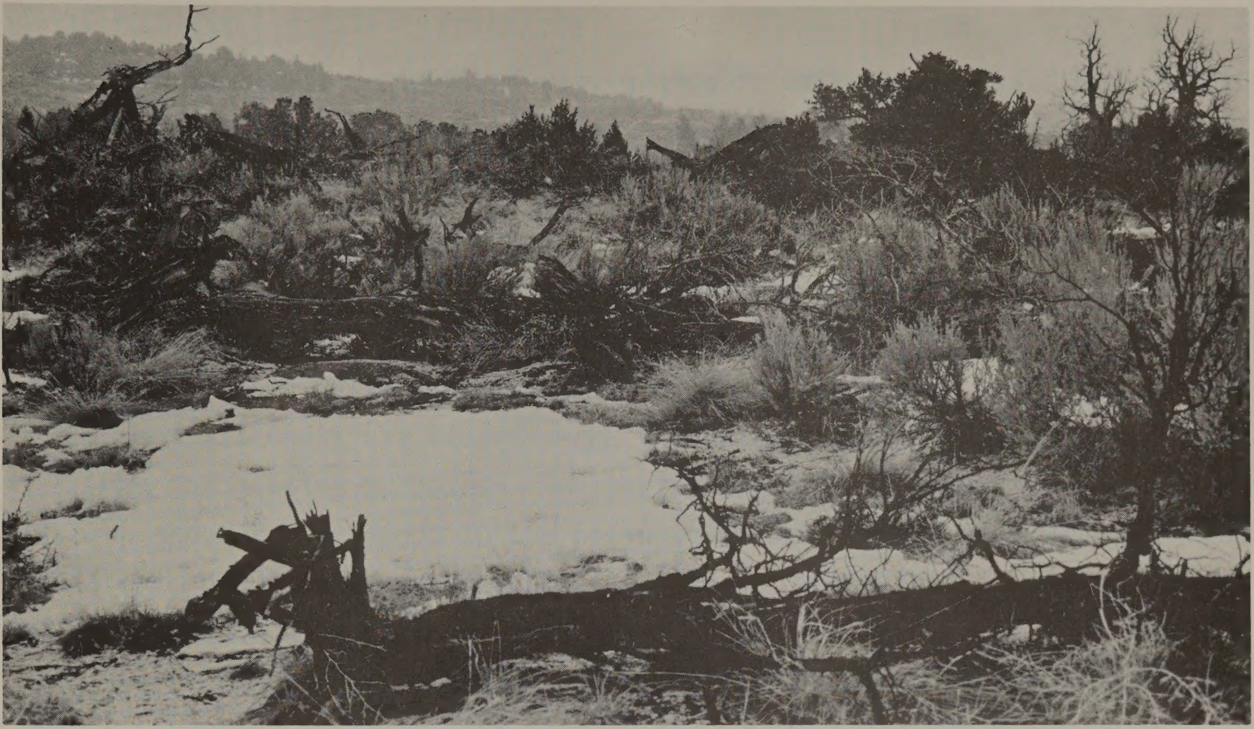


Figure 3.4 Chained Land in Piceance Creek basin

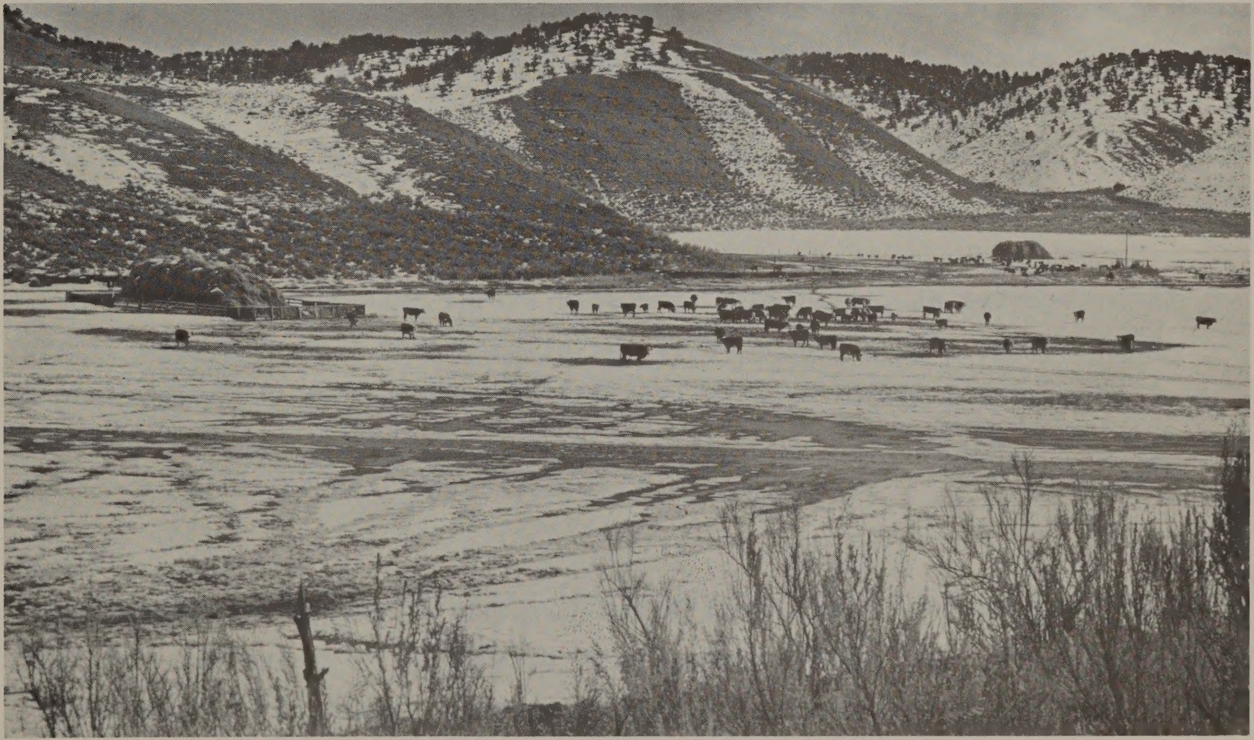


Figure 3.5 Cattle Grazing on Floodplain of Piceance Creek

dirt fill in pipeline rights of way, generally with good yield. Availability of sufficient ground moisture in this semi-arid region is the most important factor in development of forage grass.

3.1.8 Land Use and Population

Agriculture, primarily grazing, is the traditional land use in the Piceance Creek area. Much of the oil shale land is privately owned by oil companies, either surface ownership or mineral rights with extensive surface rights and alternate use restrictions. Much of this land is leased to local ranchers for grazing purposes. Smaller stream valleys support a small amount of cropland. Public lands in the basin serve as forage areas, wildlife habitat, coal, oil, natural gas and natural gas liquids production, as a watershed, and for outdoor recreation, Figure 3.5.

The Piceance Creek basin is 200 miles from major population centers of Denver, Colorado and Salt Lake City, Utah. Urban settlements occupy less than 15 square miles of the total 9,563 square miles in Garfield, Mesa and Rio Blanco counties. Towns closest to the basin are: Dinosaur, Rangely, Meeker, Glenwood Springs, Rifle, Grand Valley, and DeBeque. The basin is bounded by U.S. Highway 6 along the Colorado River, Colorado Highway 64 along the White River, and Colorado Highways 13 on the east and 139 on the west, Figure 3.6. The interior of the basin has numerous unsurfaced roads and trails that lead from the main access routes.

Only 150 people live in the Piceance Creek basin, an average of one person per 11 square miles. According to the 1970 census, population of nearby Rangely, Meeker, Rifle, Grand Valley, and DeBeque totals 5,763.

3.2 SITE DESCRIPTION

3.2.1 Location

The site selected for the pilot mine is in central Piceance Creek basin near the confluence of Ryan Gulch and Piceance Creek. The site is within approximately four square miles clustered around Horse Draw, an intermittent stream valley, Figures 3.7, 3.8, Table 3.2.

3.2.2 Physiography

Physiography is controlled by rock type faults and fractures, and stream

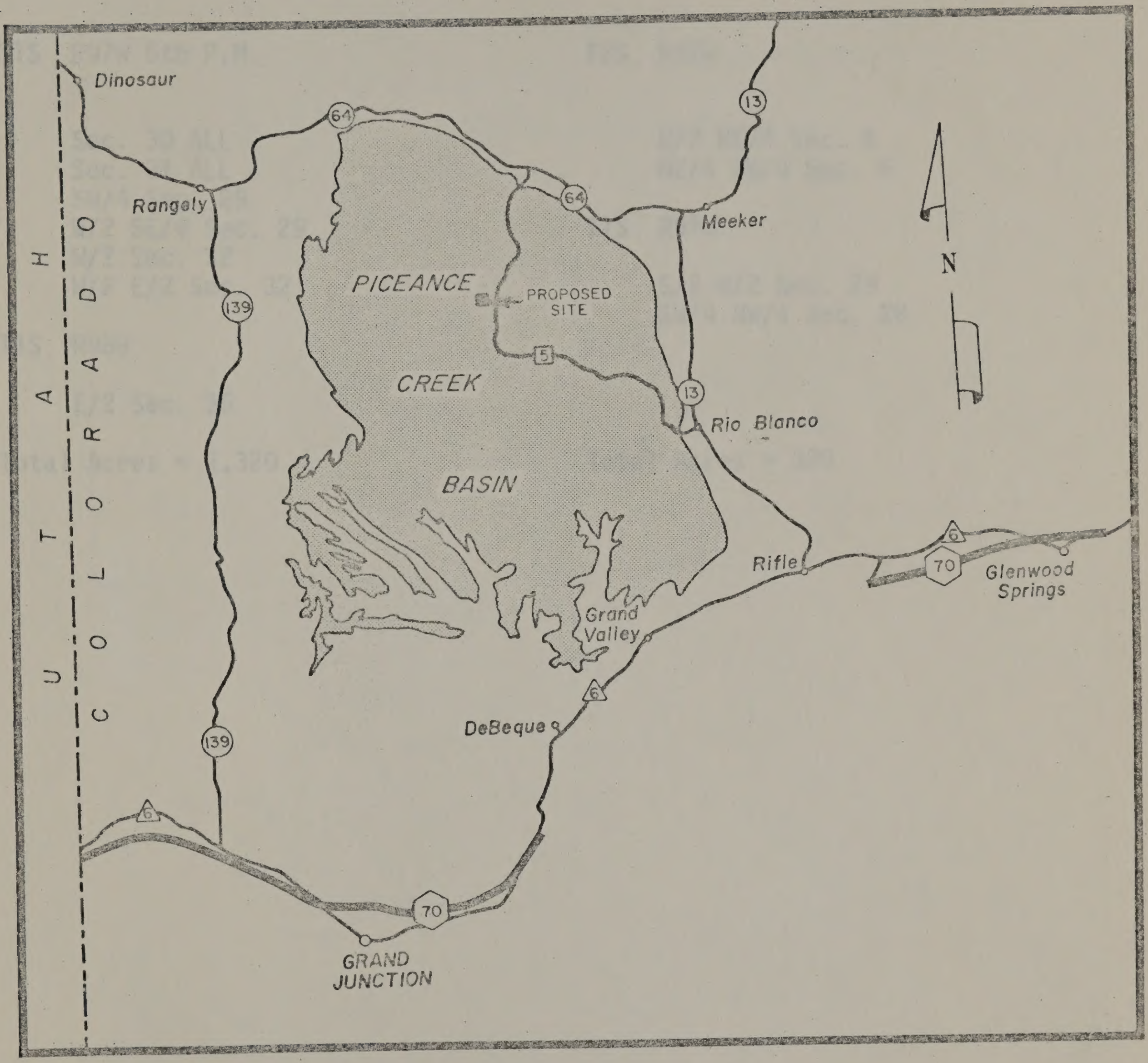


Figure 3.6 Roads and Towns Surrounding Piceance Creek Basin

Table 3.2 Legal Description of Public Lands for Pilot Mine Facility

Surface and Mining Use	Surface Use Only
T1S R97W 6th P.M.	T2S R97W
Sec. 30 ALL	N/2 NE/4 Sec. 6
Sec. 31 ALL	NE/4 NW/4 Sec. 6
SW/4 Sec. 29	
W/2 SE/4 Sec. 29	T1S R97W
W/2 Sec. 32	
W/2 E/2 Sec. 32	S/2 N/2 Sec. 29
	SW/4 NW/4 Sec. 28
T1S R98W	
E/2 Sec. 36	
Total Acres = 2,320	Total Acres = 320

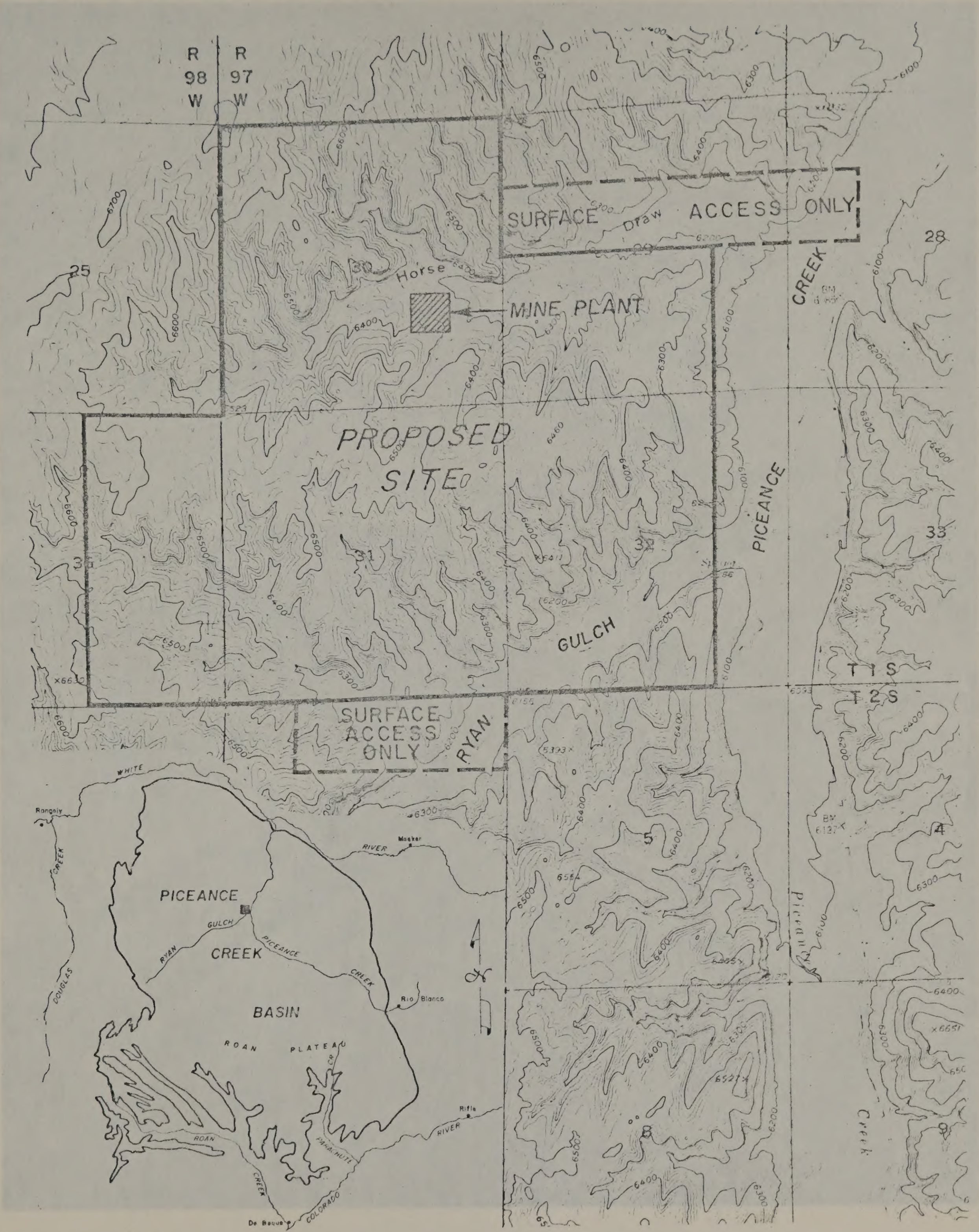


Figure 3.7 Proposed Site Location

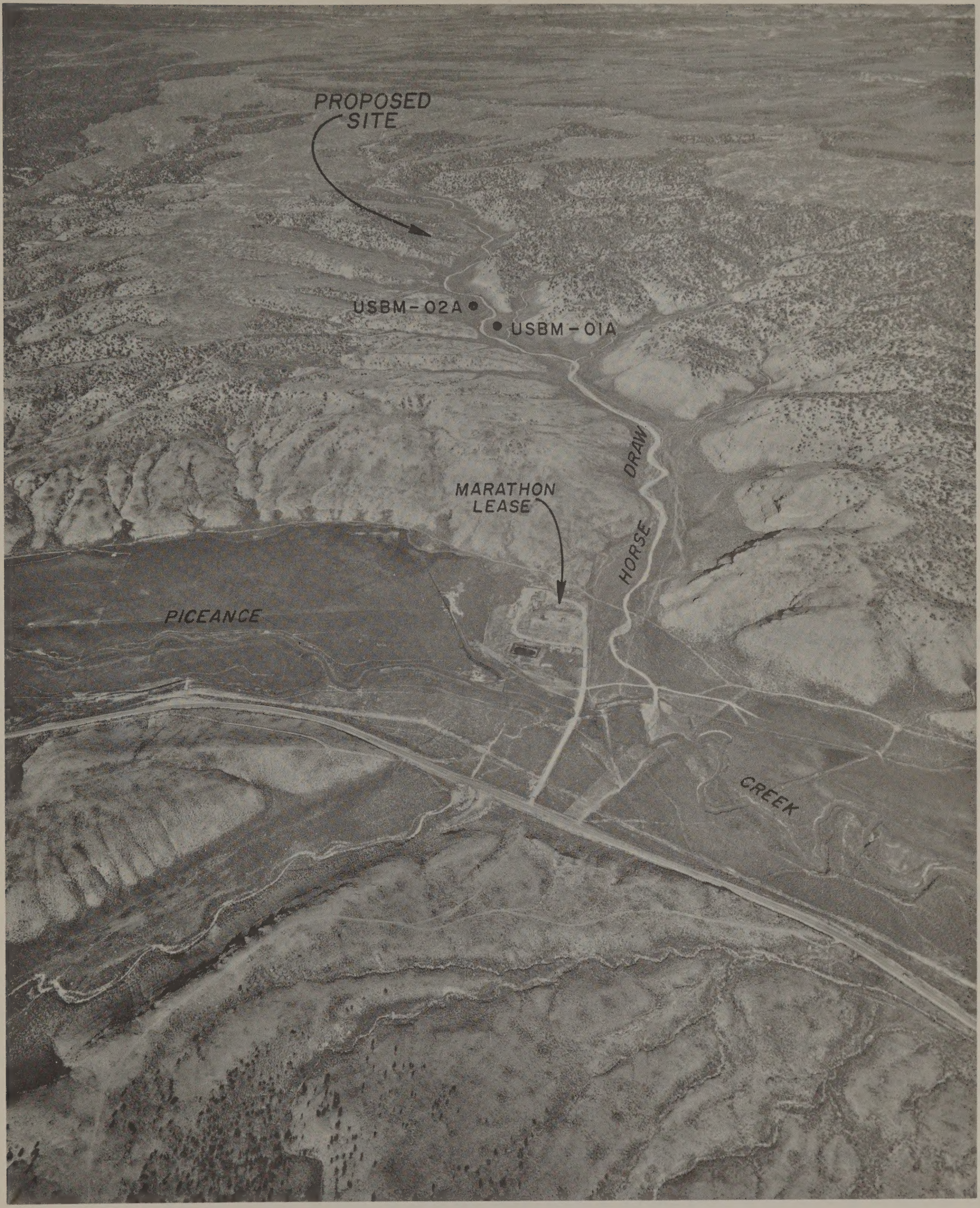


Figure 3.8 Oblique Air Photo of Proposed Site

erosion. In this part of the Piceance Creek basin, the Uinta Formation, which outcrops on site, is a thin to massive bedded yellowish-orange sandstone that tends to erode into canyon and ridge topography.

Two joint sets have been measured at the Anvil Points mine (6), trending N40°E and N63°E. Horse Draw and its tributaries appear to be at least partially controlled by these same joint orientations. South of the site a large fault trends approximately N60°W. Many streams on the east side of Piceance Creek are controlled by this fracture set.

Erosion along the joints has been severe, resulting in steep sided canyons with flat tops. As a result, the ground surface has a very chopped appearance.

The lowest elevation in the area is 6,100 feet at Piceance Creek and Ryan Gulch. The highest elevation is approximately 6,450 feet at the head of Horse Draw.

3.2.3 Soil

Two soil types are found on the selected site. Classified according to the 7th Approximation of Soil Classification, these are Eutroboralfs - Rock Outcrops - Haploborolls, and Ustifluvents - Fluvaquents (7). The Eutroboralfs Soil Association is found in the upland areas, while the Ustifluvents is found in stream valleys and low terraces.

The upland soils have developed from shales and sandstones of the Uinta Formation in cool temperatures. These soils are calcareous and well drained.

The uplands are vegetated by range plants and shrubs. These sparsely vegetated upland soils are extremely vulnerable to disturbances like overgrazing or oil shale development, which will accelerate wind erosion. Because of the short growing season, low precipitation, and wind, vegetation is difficult to re-establish. Although the soils of the Piceance Creek basin are generally well supplied with plant nutrients, they are very thin and cool or cold, which also limits the kind of crops that can be grown.

Soils in the stream valleys have developed from alluvium and are classified as Ustifluvents - Fluvaquents. These are cool, deep and moderately deep soils. They range in texture from moderately coarse to moderately fine, and well drained to poorly drained. They are found on nearly level and gently sloping (three to nine percent) low terraces and narrow valley flood plains.

These alluvial soils are generally warmer, and alfalfa, timothy, and other crops can be grown. They are susceptible to sheet erosion, gullying, and channel erosion. Revegetating these soils will be faster because of their greater depth and supply of plant nutrients. Erosion controlling engineering practices and revegetation will be necessary (8).

3.2.4 Climate

lease tract data

Climate of the Piceance Creek basin is characterized by abundant sunshine, low precipitation, warm summer temperatures, and low relative humidity. Areas with this type of climate are classified as arid steppe. The local climate is strongly influenced by slope, aspect, elevation, soil type, soil moisture content, and vegetation. Fair weather surface wind patterns and vertical temperature profiles depend almost entirely upon local topography. Unfortunately, complete long-term weather records for the Piceance Creek basin are nonexistent.

3.2.4.1 Precipitation

Average precipitation across the basin is strongly influenced by local terrain and elevation. For example, Meeker at an elevation of 6,347 feet, receives nearly twice as much precipitation as Rangely, elevation 5,216 feet. From short term records at a few locations, an average precipitation of 25 inches is estimated for the basin top. One of the most important parameters in development planning, rainfall intensity, has not been measured in this area.

Approximately one-fourth to one-half of the basin's precipitation occurs as snow. Snow depths may reach several feet in mid-winter in lower parts of the basin. This snow melts quickly below elevations of 7,000 feet, because of the clear skies and intense solar radiation.

3.2.4.2 Air Temperature

Climates like the Piceance Creek basin's often have extreme daily and annual temperature ranges. Because of the aridity and strong solar radiation, mid-summer afternoon temperatures are often quite high. Due to cold air drainage, lower valleys may have mid-winter temperatures well below minus 20 degrees Fahrenheit.

Last spring frost is usually about June 1 in the White and Colorado River valleys. First autumn frost usually occurs in mid-September. Average frost

penetration into the soil is 24 inches, and a ten year maximum is 50 inches.

3.2.4.3 Wind

Only very scanty data are available for analyzing wind circulation in the Piceance basin. Prevailing winds are from the southwest throughout the year. Local characteristics of topography, surface flow, and synoptic gradient flow control local wind circulation. Generally, however, during the daytime air will move vertically, and upvalley due to terrestrial heating. At night, air at high elevations loses heat and tends to drain downvalley. Temperature inversions are thus created in the valleys, but probably do not last through the next afternoon (9).

3.2.5 Vegetation

In any specific location, vegetation in the Piceance Creek basin is closely related to elevation, aspect or direction of slope, degree of slope, wind direction, soil characteristics, and grazing and browsing patterns. The plants of the region are well adapted to the particular combinations of physical and biological factors in each habitat. Vegetation types most susceptible to disturbance are those in areas with the greatest soil development and best microclimate conditions. Species palatable to wildlife are often damaged, and less palatable plants benefit from decreased competition.

In the proposed pilot mine site, the most common vegetation types are pinon-juniper with mountain mahogany, serviceberry, and sagebrush understory. Alluvial soils support tall sagebrush with little understory; in saline or mineralized alluvium greasewood and shadscale are found. Palatable forbs are mountain mahogany, bitterbrush and serviceberry. These vegetation types are found in fairly extreme environments, and therefore are relatively stable with respect to mechanical disturbance. Destruction of the land surface will, of course, adversely affect the vegetation.

3.2.6 Surface Water

The proposed mine site is located on Horse Draw about 1.5 miles upstream from its confluence with Piceance Creek, Figure 3.7. Piceance Creek flows all year and Horse Draw is an intermittent stream.

The U.S. Geolgoical Survey maintains a gaging and water quality station

on Piceance Creek below its confluence with Ryan Gluch. Average streamflow at this station, using 10 years of record, is 17.7 cubic feet per second (cfs), or 12,820 acre-feet per year. Total drainage area above the station is 485 square miles. During the water year October 1972 to September 1973, the dissolved solids concentration in water samples taken at the Piceance Creek station at Ryan Gulch ranged from 851 to 1,330 milligrams per liter (mg/l).

For comparison, stream flow in Piceance Creek at the White River averaged 21.8 cfs or 15,790 acre-feet per year for six years of record. Dissolved solids concentration in samples during the October 1972 to September 1973 water year ranged from 1,040 to 2,470 mg/l.

Selected water quality parameters are shown in Figures 3.9 through 3.13. Note the relationship between streamflow, total dissolved solids and sediment load of Piceance Creek at two locations. The wide range in water quality through the year is also documented.

3.2.7 Groundwater

Two test wells were drilled by the Bureau of Mines on the Horse Draw site during November and December 1975, and January 1976, Figures 3.14 and 3.15.

Drill hole USBM-01A: Drilling began on November 7, 1975, and was completed on November 22, 1975. A rock bit was used from the surface to a depth of 830 feet. From 830 feet to 2,547.6 feet, 4-inch diameter continuous core was taken. The hole was deepend from 2,547.6 to a TD (total depth) of 2,610 feet using a rock bit.

Drill hole USBM-02A: Drilling commenced on December 8, 1975, and was terminated on January 24, 1976. Intervals drilled with a rock bit include 0-197.5, 212.5-217.5, 975.5-983, and 1,451-1,458 feet. The remainder of USBM-02A was continuously cored; 4-inch diameter core was taken to TD of 2,660.0 feet.

Two aquifer tests were completed in well 02A, the first on the upper aquifer, and the second test on the lower aquifer. Preliminary analyses of test 1 data indicate a transmissivity of 2,500 ft^2/day for the upper aquifer. Time draw-down data describe a curve typical of vertically fractured wells, suggesting that well 02A may be in or near a vertically fractured zone. This interpretation, combined with test data from 01A, indicates that anisotropic

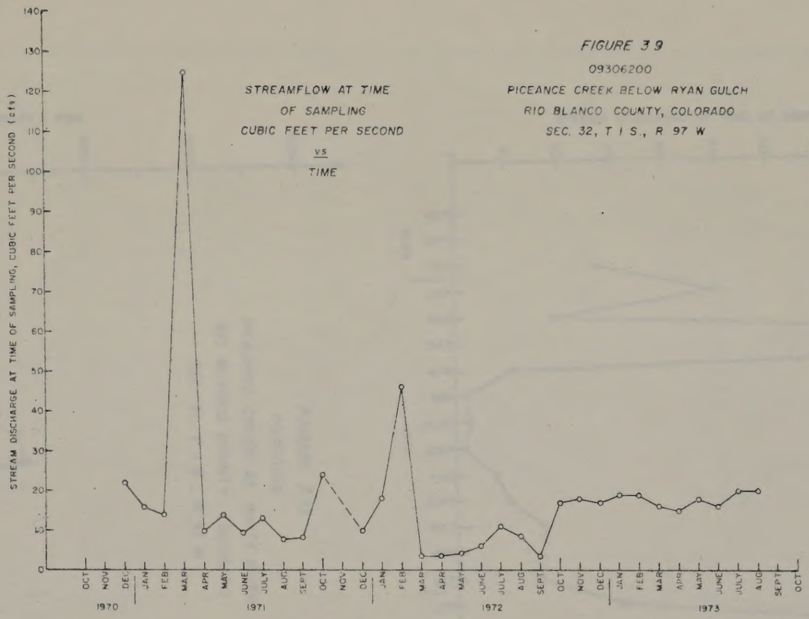


FIGURE 3.9
09306200
PICEANCE CREEK BELOW RYAN GULCH
RIO BLANCO COUNTY, COLORADO
SEC. 32, T 1 S., R 97 W

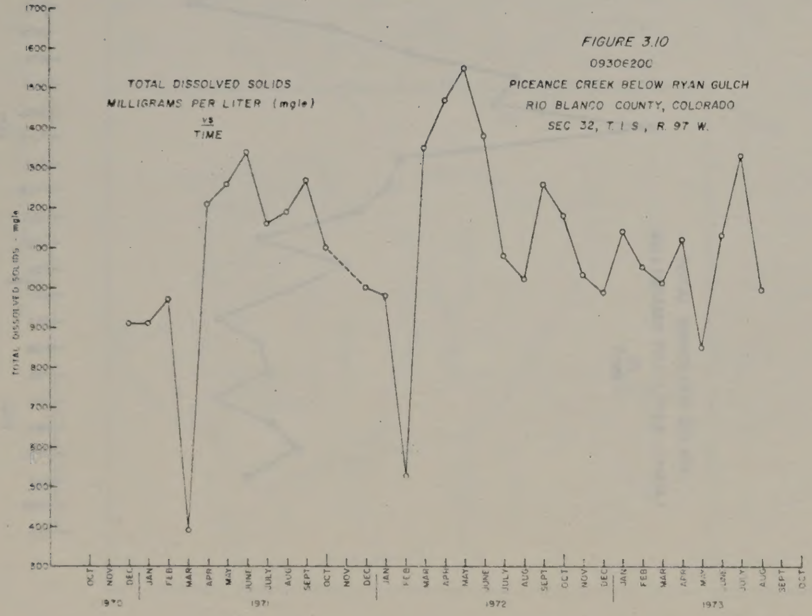


FIGURE 3.10
09306200
PICEANCE CREEK BELOW RYAN GULCH
RIO BLANCO COUNTY, COLORADO
SEC 32, T 1 S, R 97 W.

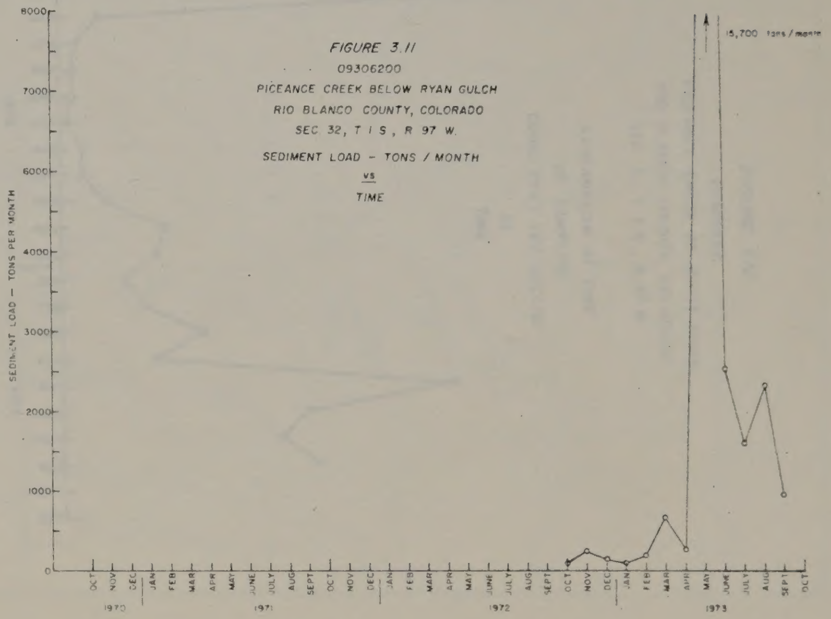


FIGURE 3.11
09306200
PICEANCE CREEK BELOW RYAN GULCH
RIO BLANCO COUNTY, COLORADO
SEC 32, T 1 S, R 97 W.

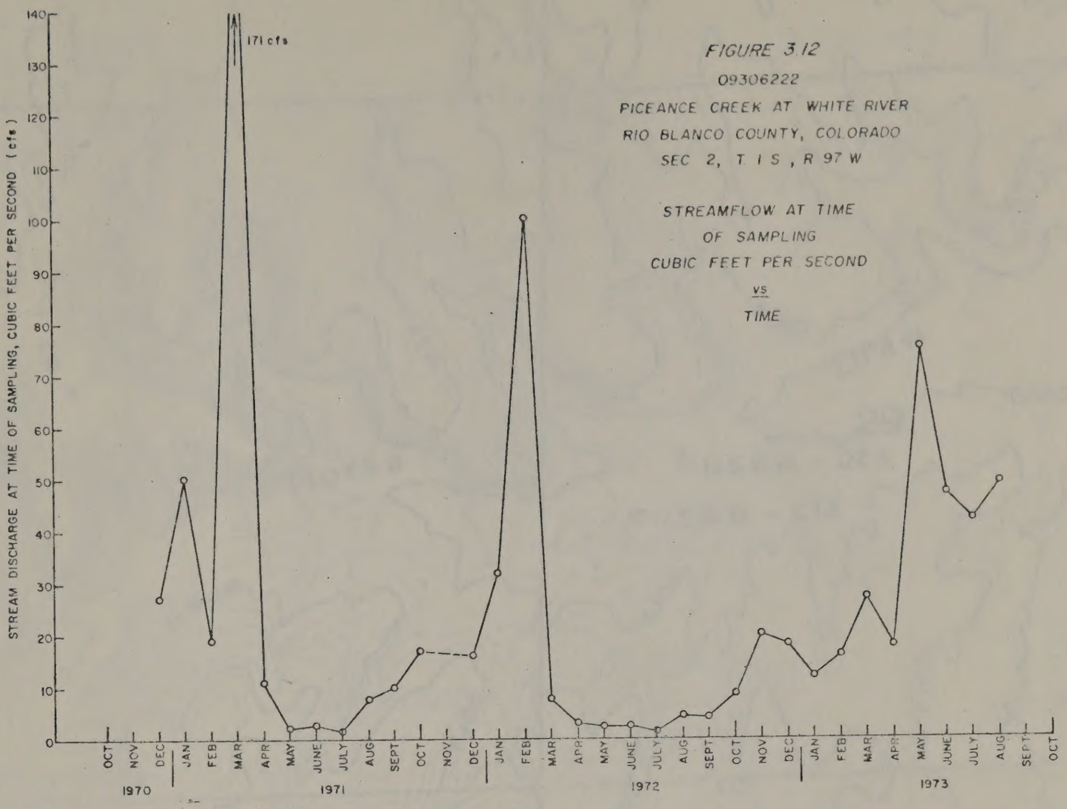


FIGURE 3.12
09306222
PICEANCE CREEK AT WHITE RIVER
RIO BLANCO COUNTY, COLORADO
SEC. 2, T. 1 S., R. 97 W.

STREAMFLOW AT TIME
OF SAMPLING
CUBIC FEET PER SECOND
vs
TIME

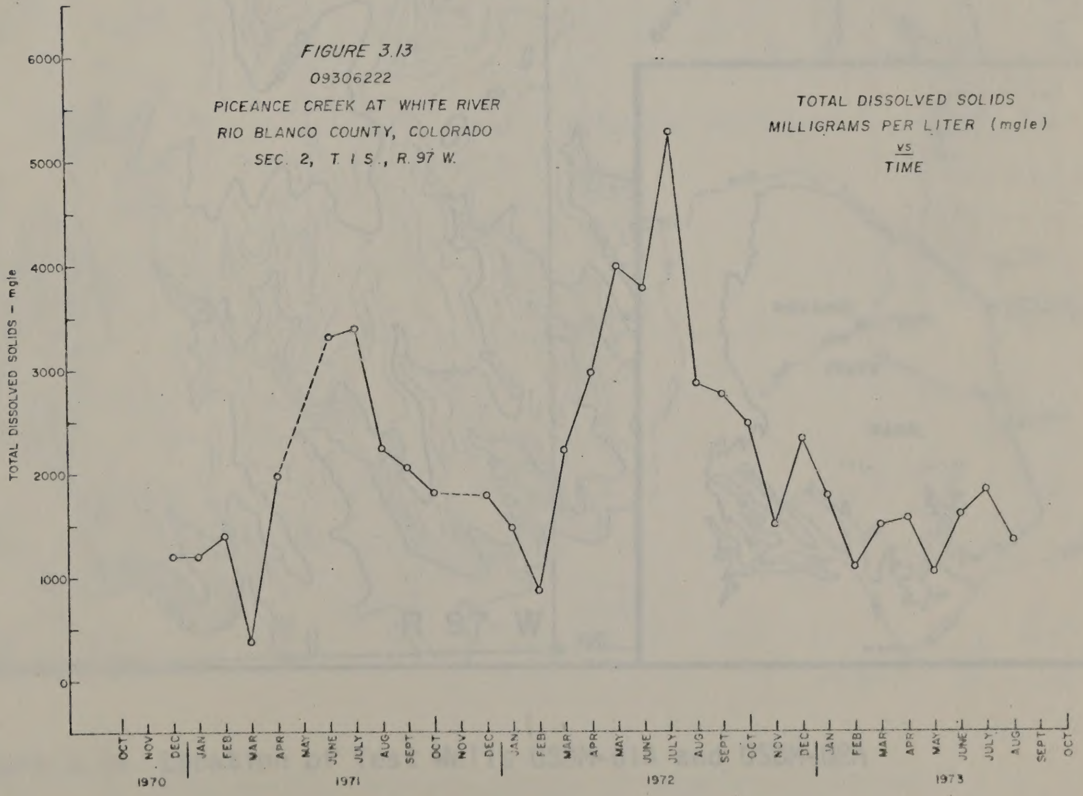


FIGURE 3.13
09306222
PICEANCE CREEK AT WHITE RIVER
RIO BLANCO COUNTY, COLORADO
SEC. 2, T. 1 S., R. 97 W.

TOTAL DISSOLVED SOLIDS
MILLIGRAMS PER LITER (mgle)
vs
TIME

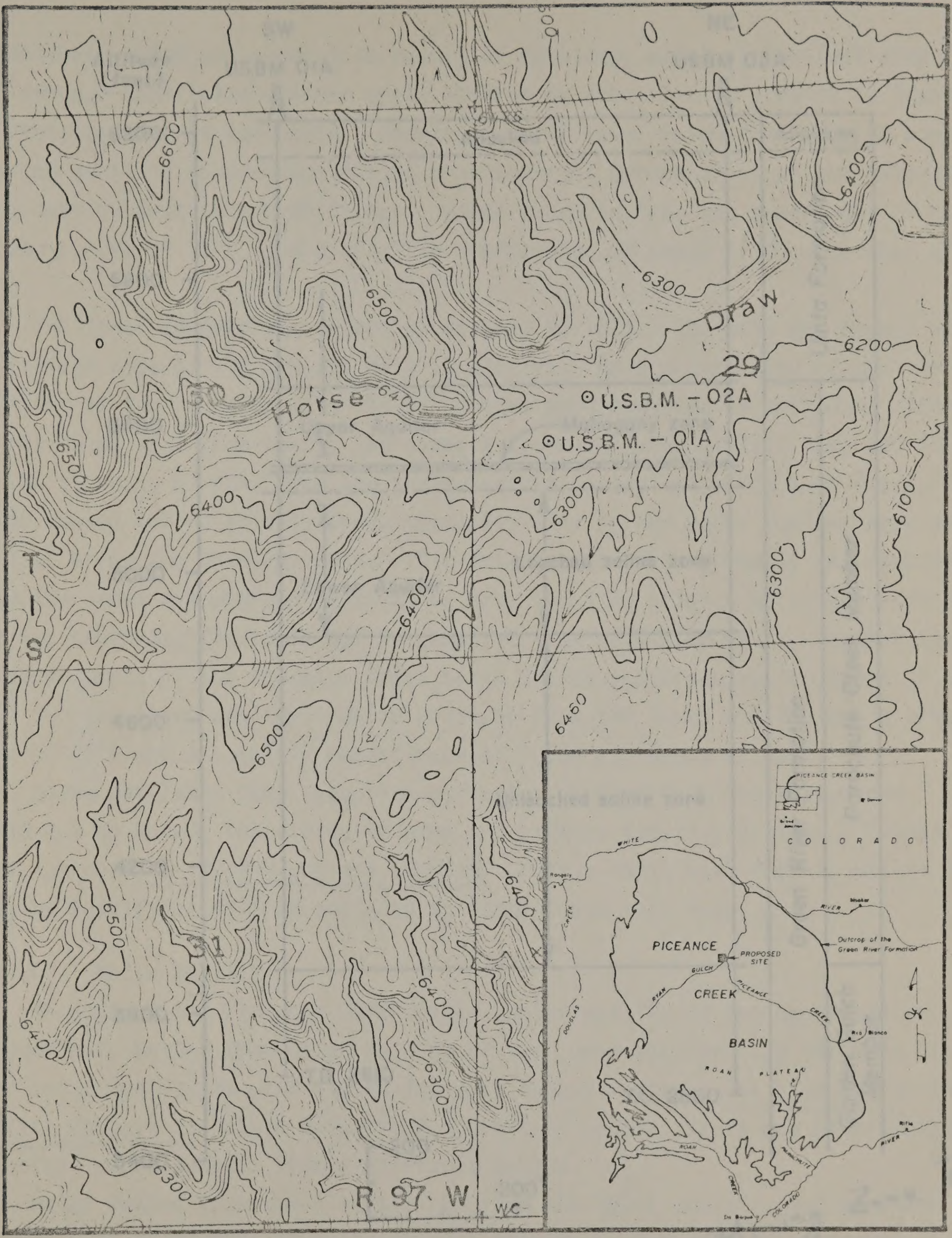
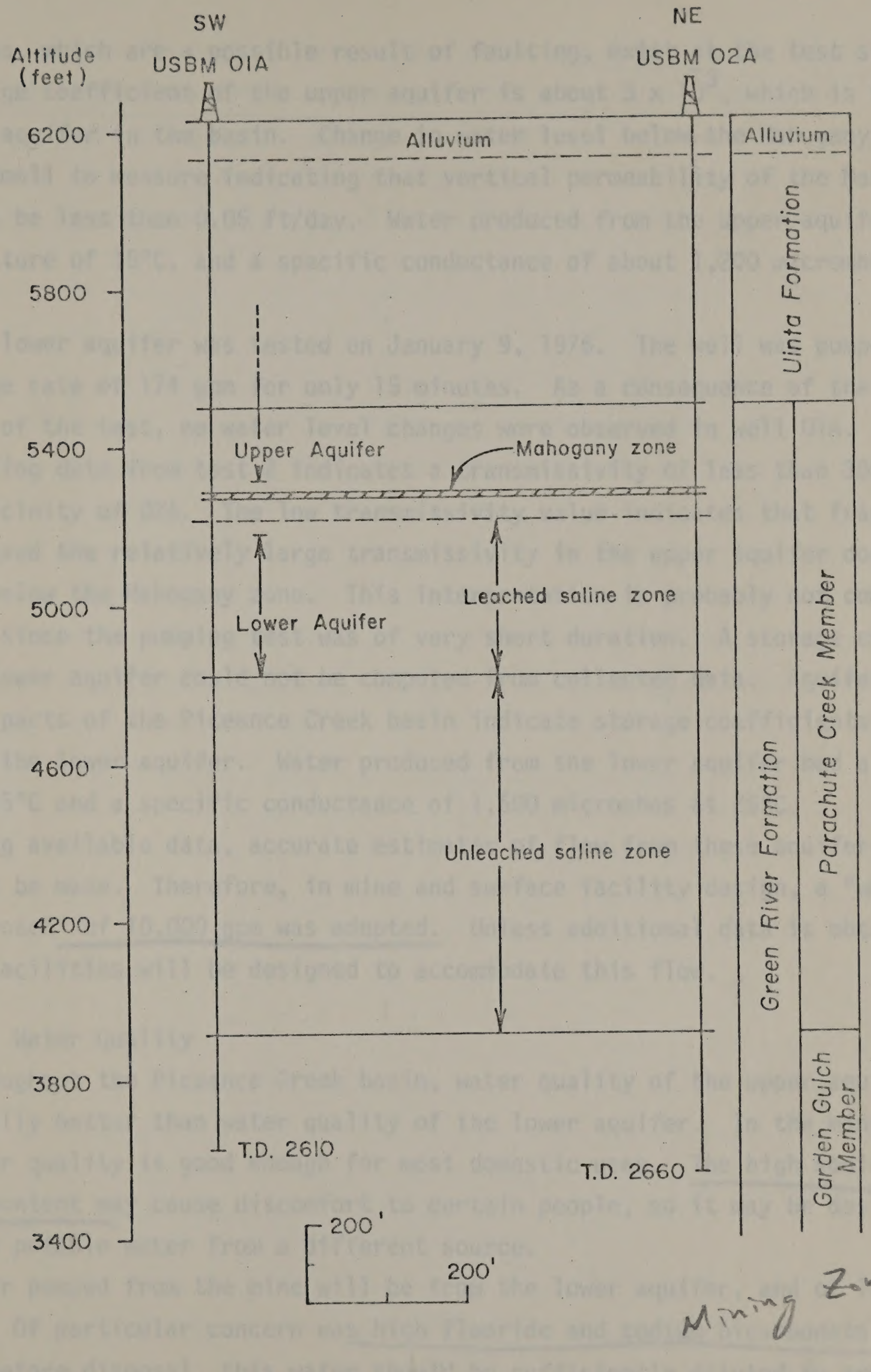


Figure 3.14 Location of Test Wells USBM-01A and USBM-02A



Mining Zone?

Figure 3.15 Diagrammatic Representation of Aquifer Locations

conditions, which are a possible result of faulting, exist at the test site. The storage coefficient of the upper aquifer is about 3 x 10^{-3}, which is typical for this aquifer in the basin. Change in water level below the Mahogany zone was too small to measure indicating that vertical permeability of the Mahogany zone must be less than 0.05 ft/day. Water produced from the upper aquifer had a temperature of 15°C, and a specific conductance of about 1,200 micromhos at 25°C.

The lower aquifer was tested on January 9, 1976. The well was pumped at an average rate of 174 gpm for only 15 minutes. As a consequence of the limited duration of the test, no water level changes were observed in well 01A. Analysis of resulting data from test 2 indicates a transmissivity of less than 300 ft^2/day in the vicinity of 02A. The low transmissivity value indicates that fracturing which caused the relatively large transmissivity in the upper aquifer does not persist below the Mahogany zone. This interpretation is probably not completely accurate since the pumping test was of very short duration. A storage coefficient for the lower aquifer could not be computed from collected data. Aquifer tests in other parts of the Piceance Creek basin indicate storage coefficients of about 10^{-4} for the lower aquifer. Water produced from the lower aquifer had a temperature of 15°C and a specific conductance of 1,600 micromhos at 25°C.

more

Using available data, accurate estimates of flow from these aquifers could not be made. Therefore, in mine and surface facility design, a "worst case approach" of 10,000 gpm was adopted. Unless additional data is obtained, pumping facilities will be designed to accommodate this flow.

3.2.8 Water Quality

Throughout the Piceance Creek basin, water quality of the upper aquifer is generally better than water quality of the lower aquifer. In the mine plant area water quality is good enough for most domestic uses. The high sodium and sulfate content may cause discomfort to certain people, so it may be desirable to obtain potable water from a different source.

Water pumped from the mine will be from the lower aquifer, and of lower quality. Of particular concern was high fluoride and sodium bicarbonate contents. Before disposal, this water should be sufficiently diluted to avoid threatening normal aquatic life and irrigation systems. Water quality regula-

tions for surface disposal of this saline water are difficult to establish as the quality of Piceance Creek varies drastically throughout the year. Therefore, a mid-range limit of specific conductance or total dissolved solids of 5,000 micromhos/cm at 25°C is suggested for the upper limit of specific conductance. This figure is approximately equivalent to 2,500 mg/l total dissolved solids.

4.0 MINE PLAN

The primary function of the pilot demonstration mine will be to test proposed mining systems that are uniquely adapted to large scale oil shale mining. These mining systems will include chamber and pillar, sublevel stoping with spent shale backfill, sublevel stoping with full subsidence and, block caving using LHD's. Several modifications have been made in the systems as originally designed (10), to adapt them to a common transportation system and smaller scale. The mining systems presented in this section probably represent the maximum dimensions needed to adequately test each technique. As a consequence, the total time allocated to test the mining systems is considered to be conservative.

A secondary function of the pilot demonstration mine will be to evaluate possible health and safety hazards, rock mechanics, ventilation and hydrological problems, transportation systems, environmental impact, equipment performance and other novel mining concepts. In addition, bulk samples of nahcolite and/or dawsonite berming ore will be provided for metallurgical testing. ?

The following subsections describe in more detail the scheduling, development and construction of the facility, mine design and operation, and abandonment and standby plans. Where necessary, typical plans or sections are presented but are not to be interpreted as the final design.

4.1 SCHEDULE

Engineering, development and construction, operation and decommissioning of the pilot mine facility will proceed in five phases. The phases and their estimated duration are shown in Figure 4.1, and described in the following subsections. The present estimated life of the project is 108 months or nine years.

4.1.1 Phase I

The first phase of the proposed pilot mine project will consist of engineering design of facilities and mine, a core drilling and geophysical program and construction of access roads, dams, shaft site, and the boring

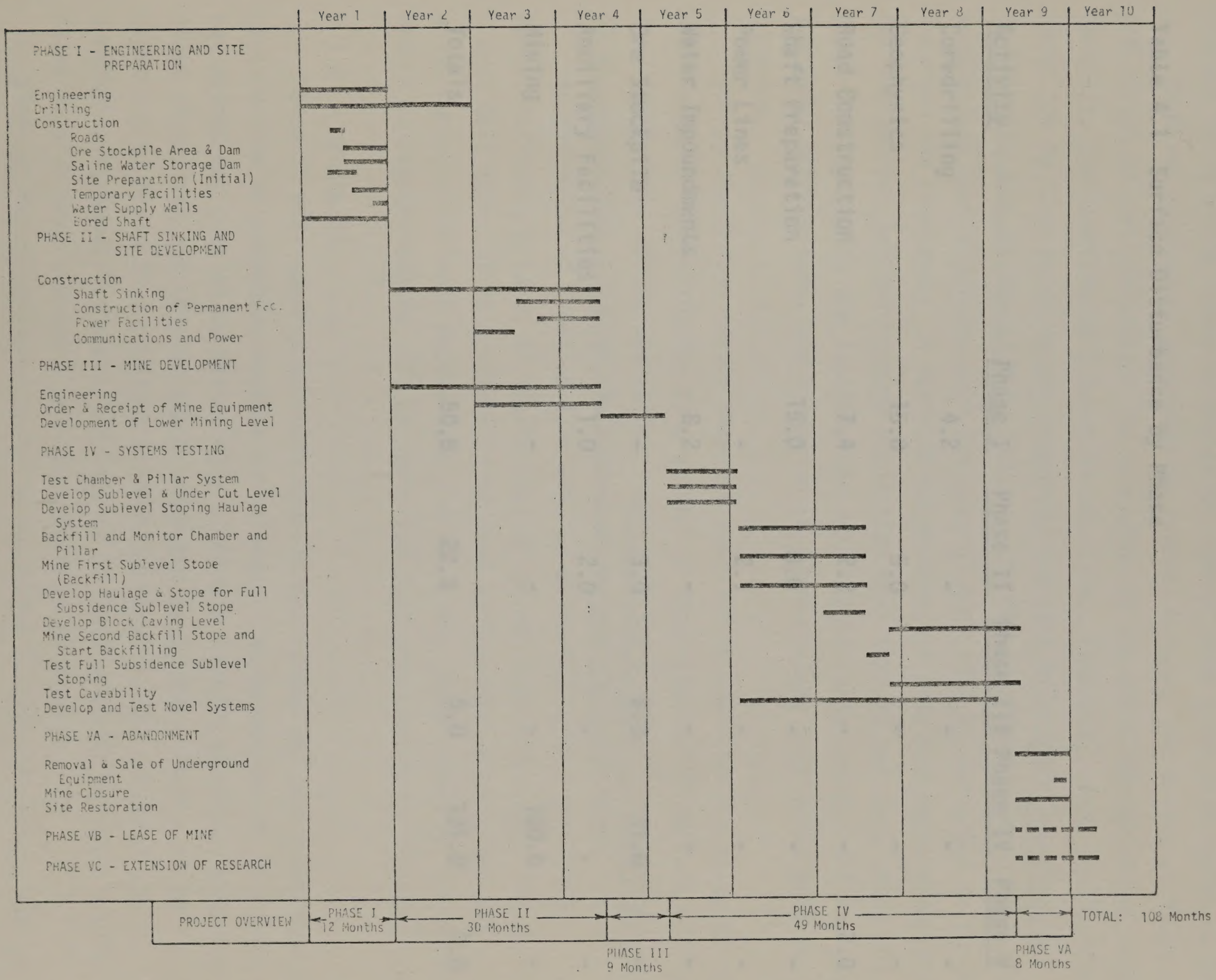


Figure 4.1 Scheduling of Project Phases

Table 4.1 Surface Disturbance by Phase

Activity	Phase I	Phase II	Phase III	Phase IV	Phase V
Coredrilling	4.2	-	-	-	-
Geophysics	15.0	5.0	-	-	-
Road Construction	7.4	2.2	-	-	2.0
Shaft Preparation	15.0	8.0	-	-	-
Power Lines	-	2.1	-	-	-
Water Impoundments	8.2	-	-	-	-
Ore Stockpile	-	3.0	5.0	31.0	-
Ancillary Facilities	1.0	2.0	-	-	-
Mining	-	-	-	100.0	-
Totals	50.8	22.3	5.0	131.0	2.0

of an 8-foot inside diameter shaft. The projected duration of Phase I activities is 12 months, (24 months for core drilling), however, preliminary engineering design started in 1975 with three coreholes drilled to date under SLUP Number C-22672.

Once an interagency agreement is reached between the Bureau of Mines and Bureau of Land Management for operation of the pilot demonstration mine facility, construction will begin on the site. Initially, core drilling of about one to five holes on the proposed mine site will start and provide engineering and geological data necessary to finalize mine designs. In addition, geophysical investigations over the general area will be conducted to further increase the data base. A contract to provide the detailed engineering plans for all surface and underground facilities will then be awarded. When the final sites for the shafts are located, the main access roads, powder and cap magazines, two water storage dams, and a portion of the ancillary facilities will be constructed.

Boring the 8-foot inside diameter ventilation shaft is estimated to take approximately ten months for completion. A total crew of 16 persons will be required for the boring operations. An estimated 9,000 yd^3 of cuttings will be discharged and placed on the bottom of the ore stockpile area.

An estimated 50 acres of land will be disturbed during the first phase, including a total of 10,700 feet of gravel and dirt roads, Table 4.1. A peak work force of 36 people will be used during this period, the majority coming from local populations. A temporary power generator and radio telephone communications will be installed just prior to Phase II operations.

4.1.2 Phase II

Phase II will consist of shaft sinking operations and the completion of construction of permanent surface structures. Two contracts, to determine the method and cost of conventionally sinking a 20-foot diameter, concrete lined production and service shaft, were let in December 1975. At the beginning of Phase II a contract will be awarded for the construction of a hoisthouse, headframe and 2,400 feet of 20-foot diameter vertical shaft. Phase II will have a duration of approximately 30 months.

Sinking the conventional shaft is estimated to take 30 months, due to

the expected need for freezing the leached zone prior to sinking. Included in the shaft construction will be excavation of the two proposed level stations at depths to be determined from analysis of additional corehole data. Crews will operate on a three shift per day, five day per week work schedule. Peak manpower will be 20 people per shift or a total crew of 60. Production tonnages from sinking and station excavation are estimated at 30,000 tons of waste and 45,000 tons of ore grade shale, Table 4.2. The excavated material will be stockpiled in a draw adjacent to the shaft site. Water from the shaft dewatering will be pumped to a saline water storage pond.

Ancillary facilities will be finished during this phase and include the office, changehouse, maintenance shop, fuel storage, and compressorhouse. A 138,000-kv power line will be run into a 5 to 10,000 kva electric substation to replace the temporary generator. Radio telephone communications are planned to be used throughout the life of the project.

4.1.3 Phase III

Phase III is the development period for the undergound mine and is estimated to last about nine months. However, the detailed engineering for underground mine layout and the ordering of equipment will be performed during Phase II.

Underground development will consist of completing the initial ventilation network to comply with Title 30, Code of Federal Regulations, for gassy mines. During this period one chamber and pillar stope will also be prepared for testing.

Total mine personnel will consist of approximately 82 people working a two shift per day, six day per week work schedule. The total production tonnage during this period is estimated at 116,000 tons, Table 4.2, and will be stored in a temporary ore stockpile. Approximately five acres of land in the ore stockpile will be covered by mine production during this period.

4.1.4 Phase IV

This phase of the pilot demonstration mine operation will consist of testing the economic and technical feasibility of several proposed mining methods. Some of these methods are chamber and pillar, sublevel stoping with spent

Table 4.2 Production Tonnage Forecast

	Cubic Yards (Broken)			Tons		
Phase	Waste	Ore	Total	Waste	Ore	Total
1	4,000	5,000	9,000	5,000	8,000	13,000
2	20,000	30,000	50,000	30,000	45,000	75,000
3	-	81,000	81,000	-	116,000	116,000
4	-	1,769,000	1,769,000	-	2,552,000	2,552,000
5	-	-	-	-	-	-
Totals	24,000	1,885,000	1,909,000	35,000	2,721,000	2,756,000

20g/t

$$\begin{array}{r} 2,721,000 \\ 20 \\ \hline 54,420,000 \end{array}$$

bbls oil

$$\begin{array}{r} 1,300,000 \\ 42 \overline{)54,420,000} \\ 42 \\ \hline 124 \end{array}$$

shale backfill, sublevel stoping with full subsidence, and block caving with LHD's. The last system will not be tested in the pilot mine, except for determinations of cavability in the leached zone.

The estimated duration of this phase is 49 months, using a total crew of 114 people working two shifts per day, six days per week. Total production over this testing period is estimated to be 2,552,000 tons, Table 4.2. If all of the ore production from Phases III and IV were stored in the ore stockpile at the end of this period, approximately 39 acres will be covered. Water from the mine dewatering system will be stored in the saline water storage impoundment for dilution and discharge, and may cover a maximum area of eight acres. Surface subsidence due to mining is expected to be minimal, covering a maximum of approximately 100 acres. The maximum vertical subsidence is expected to be no greater than two feet and produce only very slight surface strain effects. In addition, a large amount of the subsidence effects will be under the ore stockpile and therefore not be evident on the surface.

4.1.5 Phase VA

Phase VA is the abandonment phase of the proposed demonstration pilot mine and will consist of an eight month period of removal and sale of equipment, mine closure, and site restoration. No ore production will be accomplished during this period and dewatering operations will cease. The area will be returned, as nearly as possible, to its original condition, with the possible exception of the water impoundments. If conditions warrant, these dams may be left for wildlife and livestock watering areas.

A crew of 20 people will be needed to decommission the mine and perform restoration tasks. No additional land will be affected by mining operations.

4.1.6 Phase VB

This phase covers an alternative action in the event that the government decides to lease the mine facility after completion of the Bureau of Mines research program. Such alternative action will be determined by the Department of the Interior.

4.1.7 Phase VC

If additional research is necessary to determine the technical and economic feasibility of underground oil shale mining, the facility life will be extended. Should this action take place, coordination will be made between the Bureau of Mines and Bureau of Land Management representatives.

4.1.8 Standby Phase

If operating funds for the facility were reduced, the Bureau of Mines may find it necessary to place the facility on standby status. If this occured, depending upon the phase of operation at the time of reduction of funds, only a small caretaking crew will remain. This crew will consist of no more than four personnel who will have the tasks of securing the surface facilities and inspecting the mine. Mine inspection and surface security will be performed seven days per week. Primary ventilation and dewatering pumps will continue to operate.

4.2 MANPOWER REQUIREMENTS

The manning requirements for Phases I through V will vary from four to 60 people per shift. Figure 4.2 illustrates the manning requirements on a per shift and total payroll basis for the proposed project. All manpower requirements are estimates and may vary with contractor and the availability of skilled labor.

During Phase I, a 10-man construction crew, 6-man per shift drilling crew, 4-man geophysics crew and 4-man per shift shaft boring crew will be on the proposed site. These contract personnel will be hired from nearby areas if possible, and leave upon completion of their specific tasks.

Phase II involves shaft sinking and surface plant construction. The duration of Phase II will be about 2.5 years and require approximately 20 men per shift. As in Phase I, the shaft crew will be subcontracted and personnel should depart after the sinking is completed.

Phase III will have a duration of approximately nine months and employ a labor force of 44 men per shift, working two shifts per day, six days per week. Personnel hired during Phase III will remain with the project for a period of about 5 years.

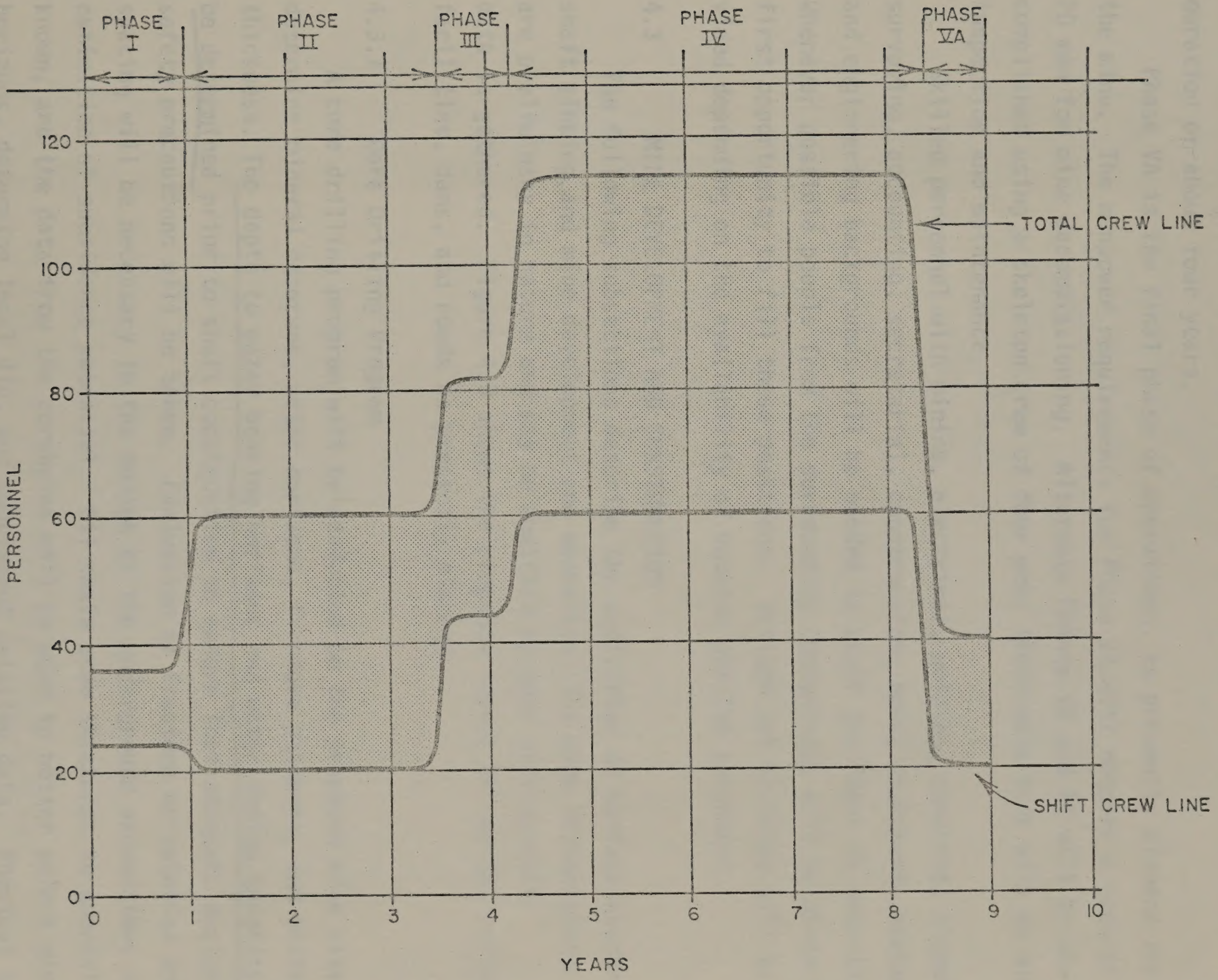


Figure 4.2 Projected Manning Requirements

Phase IV is the actual mining testing phase. During this phase an additional 20 men per shift will be hired and remain on the job for the duration or about four years.

Phase VA is the final phase of operations, as presently planned for the mine. The manpower requirements for Phase VA will require a crew of 20 men for mine decommissioning. Alternate Phases VB and VC will be accomplished using a skeleton crew of four men; their main task will be mine inspection and maintenance.

Skilled personnel with mining, electrical, welding, concrete, plumbing, surveying, accounting, secretarial, construction, heavy equipment, mechanical, and engineering backgrounds will be needed to staff the Phase IV operations. Whenever possible people from the surrounding communities will be given the first opportunity to fill these positions. Skilled job training will be provided depending on the availability of outside skilled personnel.

4.3 MINE DEVELOPMENT AND CONSTRUCTION

The following subsections describe the activities of surface construction, shaft sinking,and mine development and operation. The mine design plans are preliminary in nature and may be modified as more site specific data is gathered. Figure 4.3 shows the proposed layout of shafts, surface facilities, dams, and roads as presently planned.

4.3.1 Core Drilling Program

A core drilling program will be conducted on the proposed mine site to determine mineral reserves, water horizons, fracture patterns, and mining zone thickness. The depth to water bearing horizons and water inflow quantity must be determined prior to shaft construction to ensure that adequate design and safety precautions will be taken. Evaluation of fracture orientation and spacing will be necessary in the design of the underground excavations and estimation of subsidence potential. Oil shale zone thickness is generally known, and the data from the coreholes will be used to better select mining horizons, determine local dip, and supplement existing data. Physical testing of core will also be conducted to provide necessary engineering data for mine design.

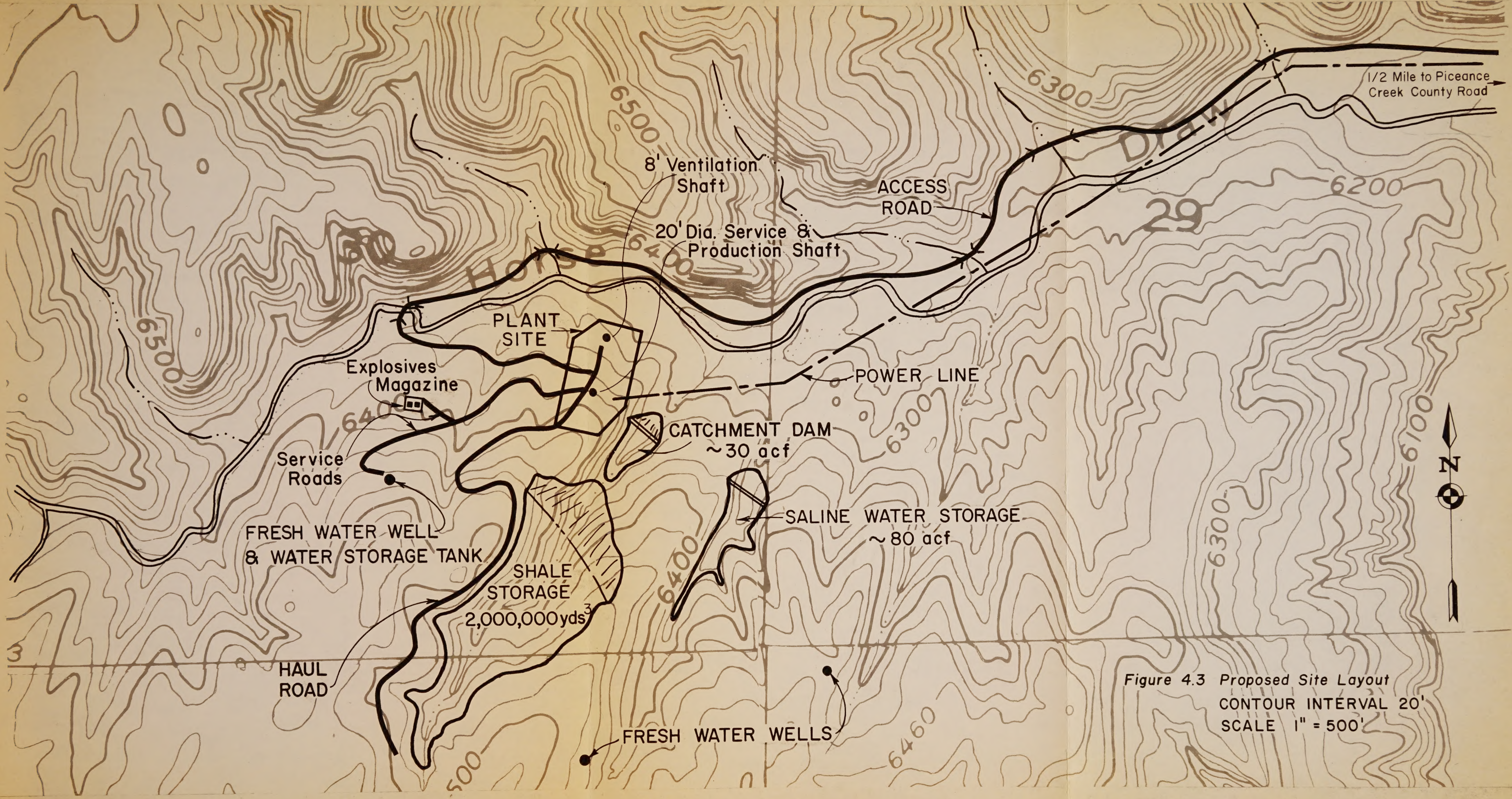


Figure 4.3 Proposed Site Layout

CONTOUR INTERVAL 20'

SCALE 1" = 500'

The core drilling layout is based on the following assumptions:

- The base of the mining horizon will be at a maximum depth of 2,400 feet below the surface.
- The first four holes will be drilled vertically.
- Water testing will be confined to one corehole at the main shaft location.
- The average collar elevation of the first four coreholes is approximately 6,355 feet.
- The long axis of the mine will be oriented S 15° W.
- The 8-foot diameter ventilation shaft will be located approximately 1,100 feet FEL and 2,100 feet FSL, Section 30, T1S, R97W.

The proposed lower mining level will cover an area on the surface approximately 2,200 by 1,200 feet, the long dimension trending S 15° W. A total of about nine coreholes will be located above this mine level, however, only four are currently planned to be drilled, Figure 4.4.

Minimum service roads will be constructed to the drill sites once necessary permits are obtained. Drilling pads, with a flat working area not exceeding one acre will be constructed with suitable mud and reserve pits. After a conductor is cemented in place, a 7.875-diameter hole will be drilled to bedrock and cased with 5.5-inch diameter pipe. A 2.5-inch diameter core will then be cut to an approximate depth of 2,550 feet. Oriented core will be taken on approximately 250-foot intervals. When coring is completed, geophysical logs of the holes will be made. Casing and conductor are pulled out of the hole when tests are completed. Two drilling pads will be located partly on the surface facilities site, and will not require immediate revegetation. The two remaining drill pads will be revegetated.

A list of the proposed holes and tests to be performed is given below. Coreholes M-0 and M-4 will be drilled on the proposed shaft locations.

- Corehole M-0: 2.5-inch core, geophysical logging.
- Corehole M-4: 2.5-inch core, geophysical logging, water tests, hole plugged with cement upon completion of tests.
- Corehole H-7: 2.5-inch core, geophysical logging, hole plugged with cement upon completion of tests.
- Corehole S-7: 2.5-inch core, geophysical logging, hole plugged with cement upon completion of tests.

After the first three coreholes are drilled, a determination of the exact strike and dip of the mining horizon will be made. If necessary, the mine layout will be rotated, such that the long axis of the mine is up dip. In

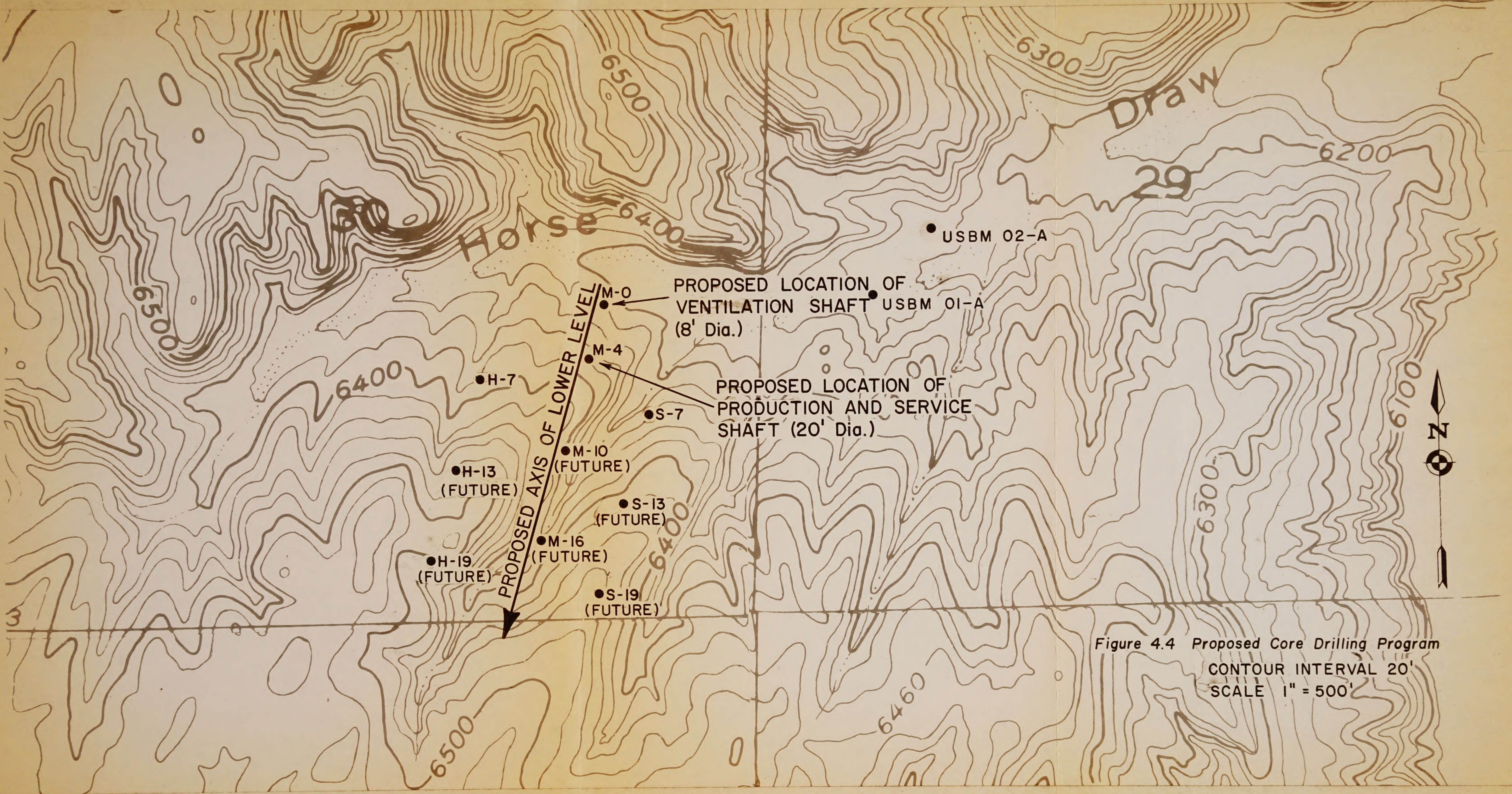


Figure 4.4 Proposed Core Drilling Program

CONTOUR INTERVAL 20'
SCALE 1" = 500'

the event that this rotation exceeds expectations, it may be necessary to re-drill corehole M-4.

From core data, a fracture pattern net will be constructed and extrapolated to cover the proposed mine site. An assessment of the effects of fracture patterns on the mining operation will then be made prior to sinking the main shaft. Water data from corehole M-4 will also be analyzed prior to sinking the main shaft.

4.3.2 Geophysical Research Program

Geophysical research will be conducted on, and in the vicinity of, the proposed tract by the PreMining Conditions Group, Denver Mining Research Center, Bureau of Mines, over a period of 20 months. Disturbance to surface vegetation will be kept to a minimum.

Part of the seismic coverage will use existing roads and trails. Vehicular off-road travel will occur between Horse Draw and Fault Draw (maximum of two lines) and in the surrounding or expanded test site area. Where necessary, in these areas four-wheel drive vehicles will be used for cross-country access. No roads will be bladed. Where possible, existing roads and trails will be used.

Line miles to be covered will include 10 miles of seismic and 25 miles for all other types. None of the other types of geophysical techniques require off-road vehicular travel. The systems will be man-carried and require only reasonably close vehicular support. Temporary survey stakes will be put in for location purposes at 50 or 100-foot intervals. Each line will be approximately 2,000 feet long.

Methods of geophysics to be used will include:

- High resolution seismic
- Shear wave seismic
- Resistivity
- Audio magneto tellurics (AMT)
- Natural tellurics
- Magnetics
- Borehole surveys (tentative)
- Other

Planned timing for the geophysical work will be approximately:

- April 15-30, 1976 - resisitivity, seismic (under existing letter agreement
- July/August, 1976 - resistivity, seismic
- September, 1976 - seismic
- May/June, 1977 - AMT, resistivity, seismic, and other

4.3.3 Mine Site Construction

The proposed site for the mine shafts and surface facilities is shown in Figure 4.3 and will cover approximately 10 acres. A balanced cut and fill method will be used in site preparation to minimize surface disturbance. The proposed site will be located on a relatively flat ridge between adjacent natural drainage systems, and graded and ditched to provide drainage into a water catchment dam below the temporary ore stockpile. Rip-rap along drainage ditch bottoms will be used wherever grades are excessive.

Placement of the site on the ridge is desirable because the depth to bedrock is much less than in the adjacent valleys. Major structures, such as the hoisthouse and headframe, will have maximum stability with lower construction cost. Mine surface facilities will include an office/changehouse, maintenance shop, fuel storage, electric power substation, hoisthouse/compressor house, headframe, ore bin, security hut, storage yard, and parking lot. The general location and scale of the facilities are shown in Figure 4.5. Detailed engineering during the first part of Phase I will determine the exact type and location of facilities. The explosives and cap magazines will be located approximately 1,000 feet to the west of the mine site. The bunkers and mine plant site will be surrounded by deer and livestock proof secured chain link fences.

Rock excavated from the shaft will be used for filling where needed, and in the final construction of the water dams. Prior to the start of excavation, the area will be cleared, grubbed, and stripped of topsoil. Topsoil will be stockpiled, or used where needed for revegetation purposes. The area will then be rough graded, ripped, and excess material used as fill or in dam construction as necessary. As fill material is placed it

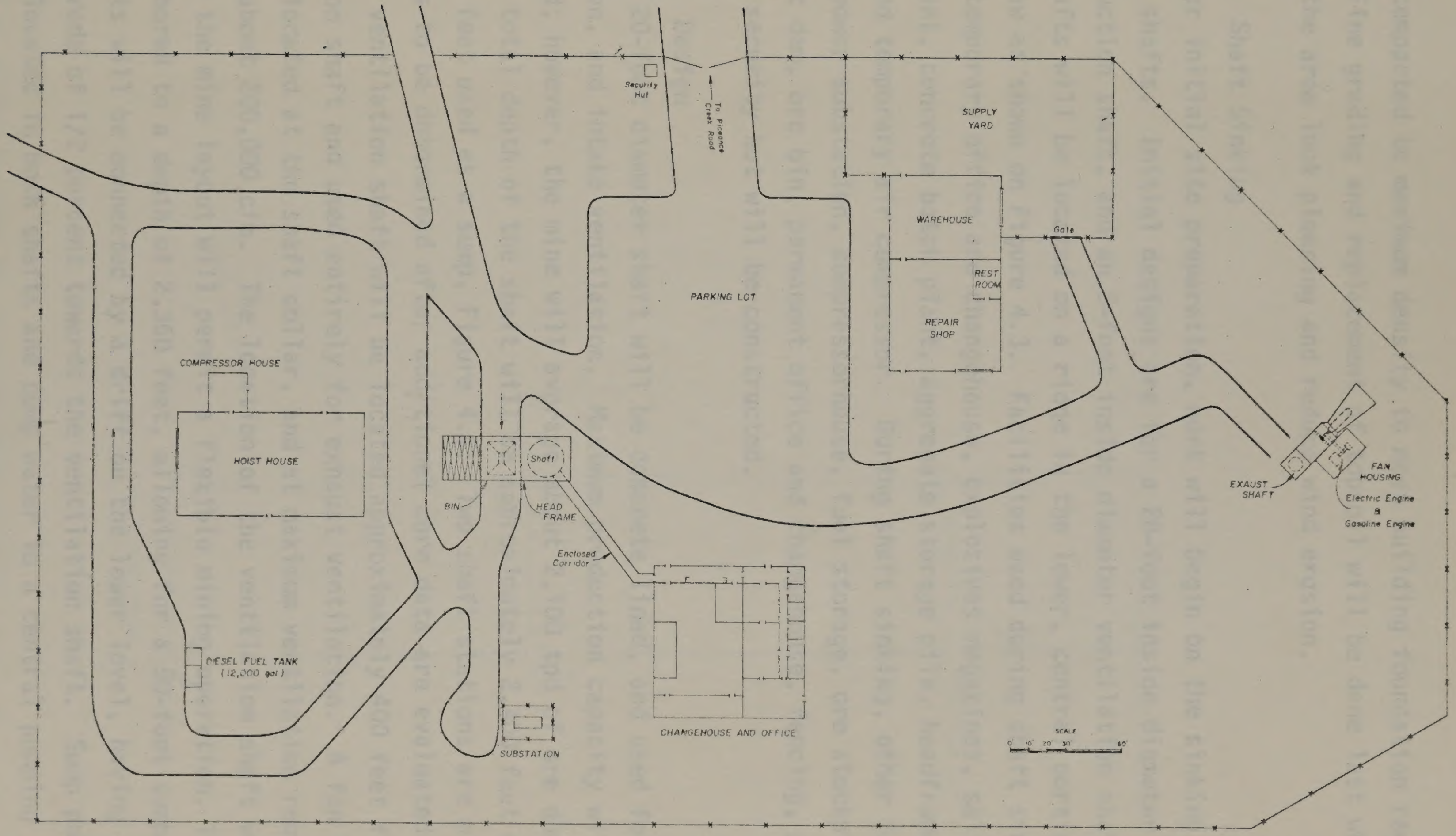


Figure 4.5 Surface Facilities Layout

will be compacted to maximum density to meet building foundation requirements. Fine grading and replacement of topsoil will be done last when possible, to make the area look pleasing and reduce wind erosion.

4.3.4 Shaft Sinking

After initial site preparation, work will begin on the sinking of two vertical shafts. Initial designs are for a 20-foot inside diameter service and production shaft, and an 8-foot inside diameter ventilation shaft. These shafts will be located on a ridge in the lower, central portion of Horse Draw as shown on Figure 4.3. Facilities used during shaft sinking will be temporary office and changehouse, explosives magazines, saline water impoundment, concrete batch plant, aggregate storage pile, headframe, hoisthouse, and temporary air compressor. During shaft sinking, other facilities such as power substation, compressorhouse, fuel storage, ore stockpile and catchment dam, ore bin, permanent office and changehouse, fencing, parking lot, and security hut will be constructed.

4.3.4.1 Design

The 20-foot diameter shaft will be concrete lined, and used for service, production, and intake ventilation. Maximum production capacity will be 7,500 tpd; however, the mine will average about 2,100 tpd of ore during Phase IV. The total depth of the shaft will be approximately 2,400 feet with the lower 50 feet used as a sump, Figure 4.6. Two shaft stations are planned at levels to be determined after additional core data are evaluated.

The ventilation shaft will be located approximately 400 feet from the production shaft and used entirely for exhaust ventilation. A fan house will be located at the shaft collar, and at maximum ventilation requirements exhaust about 200,000 cfm. The location of the ventilation shaft with respect to the mine layout will permit a flexible mining operation. This shaft will be bored to a depth of 2,360 feet, allowing for a 50-foot sump. The two shafts will be connected by a drift on the lower level, having an upward grade of 1/2 percent towards the ventilation shaft. Sump pumps will be located in both shafts and pump water to a central pumping station

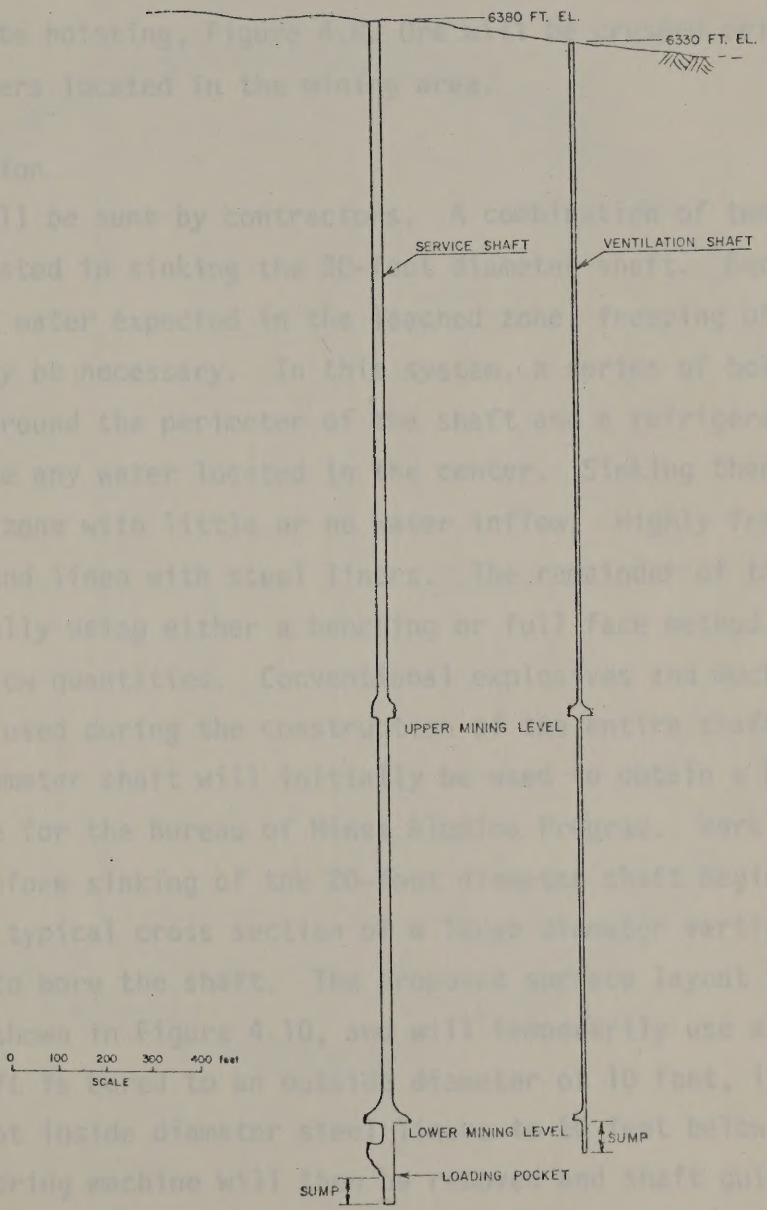


Figure 4.6 Cross Section of Proposed Mine Shafts

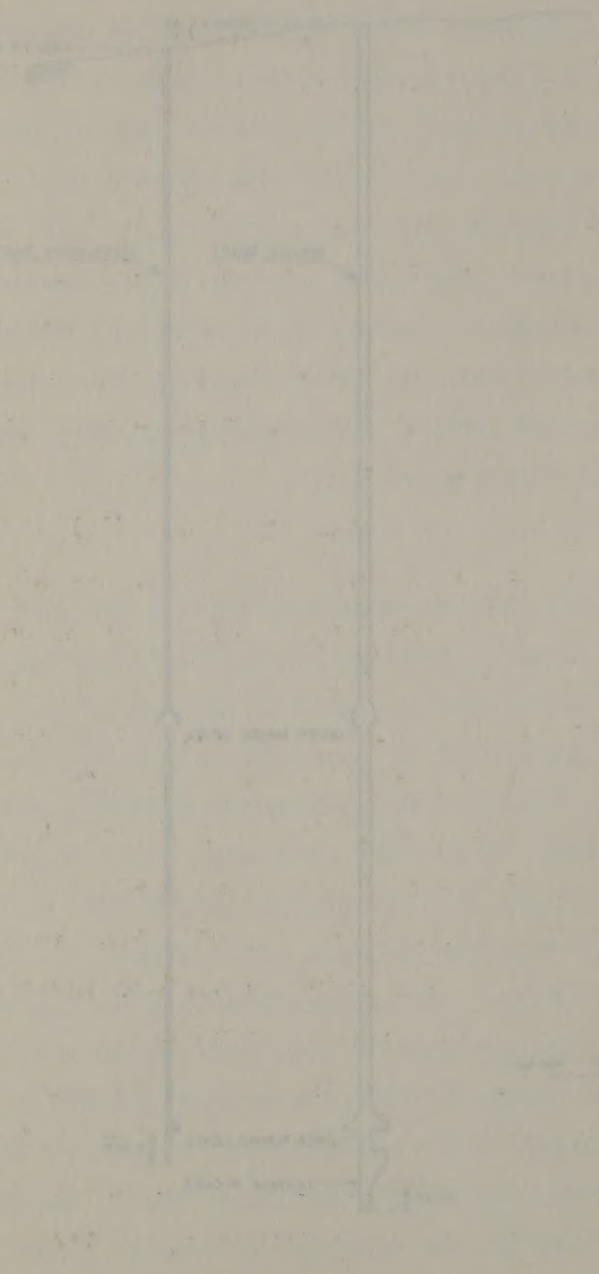


Figure 4.6 Cross Section of Proposed Mine Shafts

in the connecting drift. A total emergency reserve pumping capacity of 10,000 gpm will be installed; however the mine at this point is expected to be reasonably dry.

The production and service shaft will be designed with a hoist to operate two balanced 13.5-ton skips and a separate service cage, Figure 4.7. Skip pockets on the two mining levels will contain surge bins and measuring pockets to facilitate hoisting, Figure 4.8. Ore will be crushed prior to hoisting by feeder breakers located in the mining area.

4.3.4.2 Construction

Both shafts will be sunk by contractors. A combination of two sinking methods are anticipated in sinking the 20-foot diameter shaft. Because of the large amount of water expected in the leached zone, freezing of the upper 1,400 feet may be necessary. In this system, a series of holes are drilled and cased around the perimeter of the shaft and a refrigerant circulated to freeze any water located in the center. Sinking then proceeds through the frozen zone with little or no water inflow. Highly fractured areas are grouted and lined with steel liners. The remainder of the shaft is sunk conventionally using either a benching or full face method, depending upon water inflow quantities. Conventional explosives and mucking techniques will be used during the construction of the entire shaft.

The 8-foot diameter shaft will initially be used to obtain a bulk sample of dawsonite for the Bureau of Mines Alumina Program. Work on this shaft will start before sinking of the 20-foot diameter shaft begins. Figure 4.9 shows a typical cross section of a large diameter vertical drill that will be used to bore the shaft. The proposed surface layout for sinking operations is shown in Figure 4.10, and will temporarily use about 15 acres. As the shaft is bored to an outside diameter of 10 feet, it will be cased with 8-foot inside diameter steel liners to 50 feet below the lower mining level. The boring machine will then be removed and shaft guides installed in preparation for mining the bulk sample. A temporary headframe and hoist will then be erected and a man cage and work deck installed on the hoist cable in the shaft. A small window will be cut in the steel liner at the

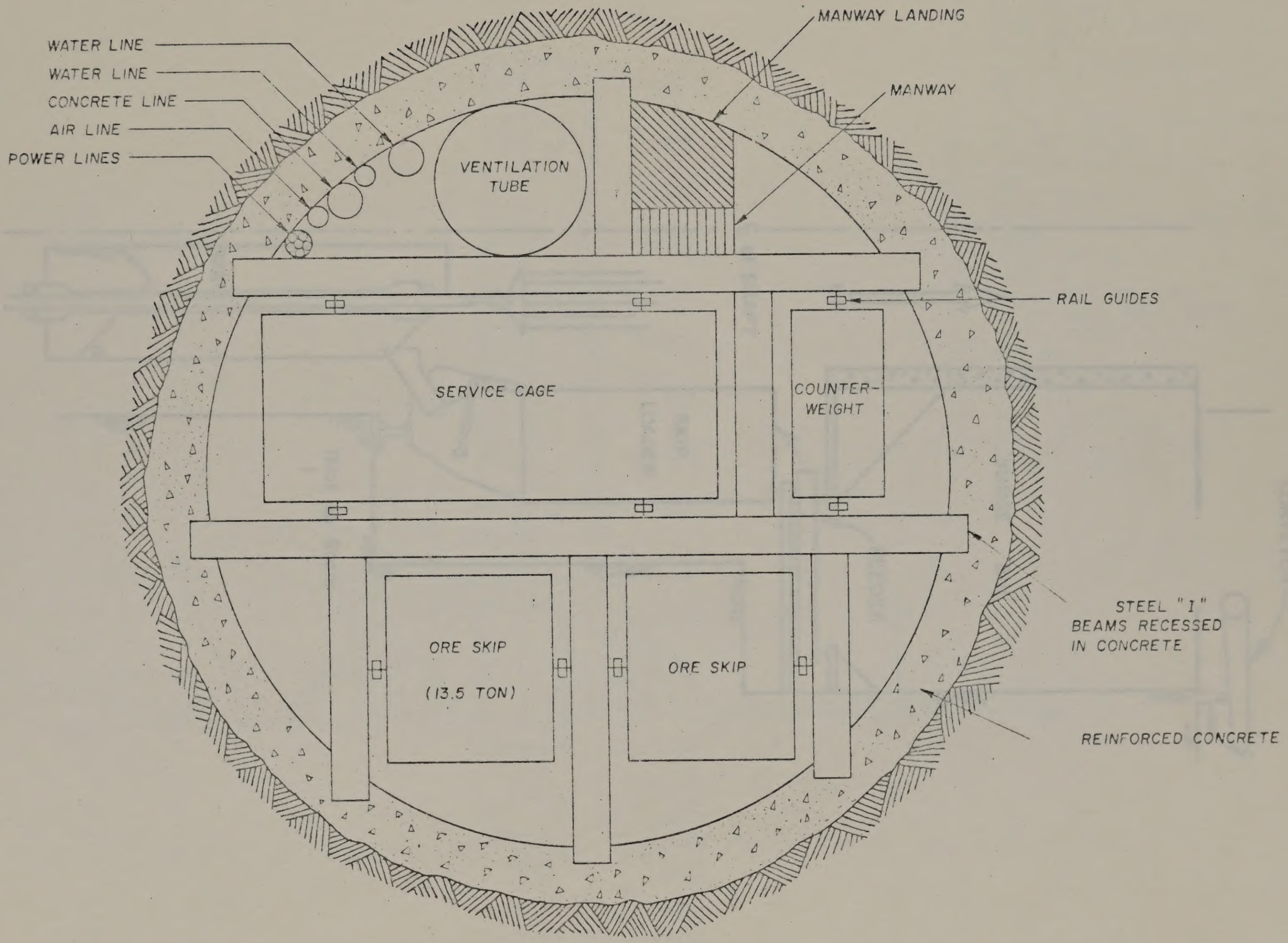


Figure 4.7 Plan View, Typical 20-Foot Inside Diameter Shaft

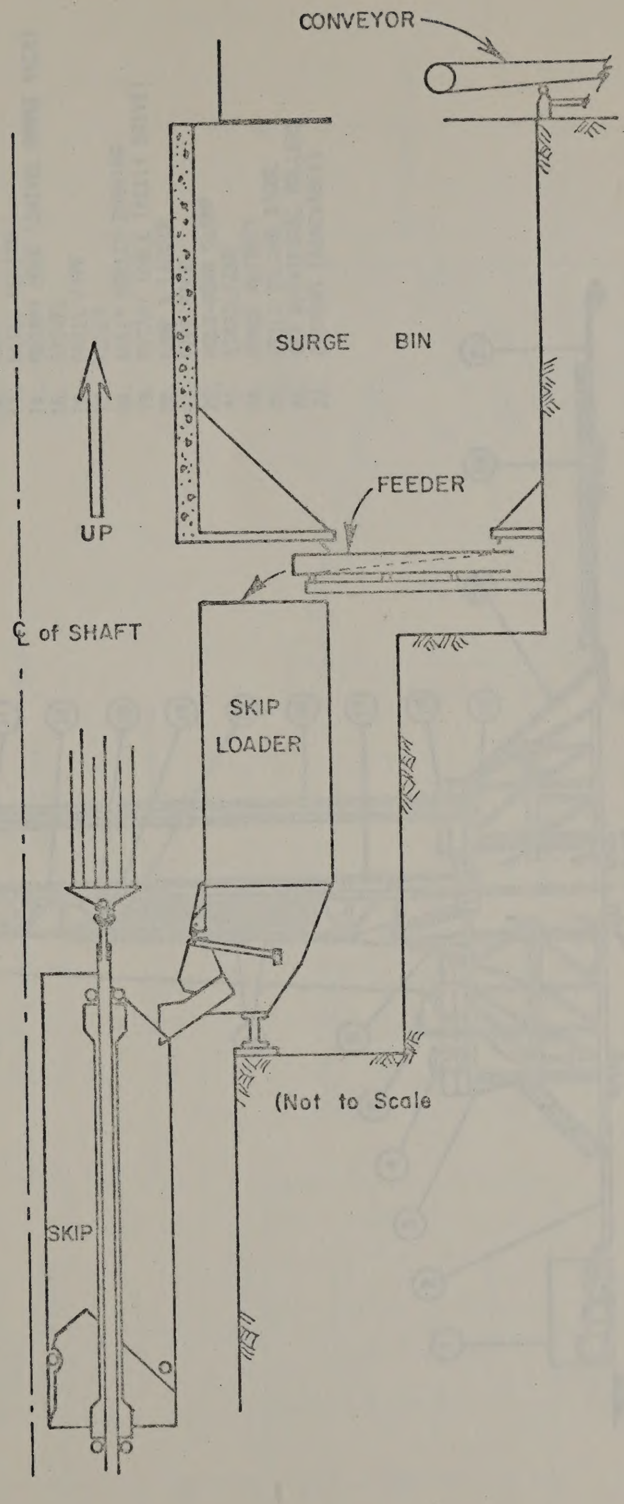
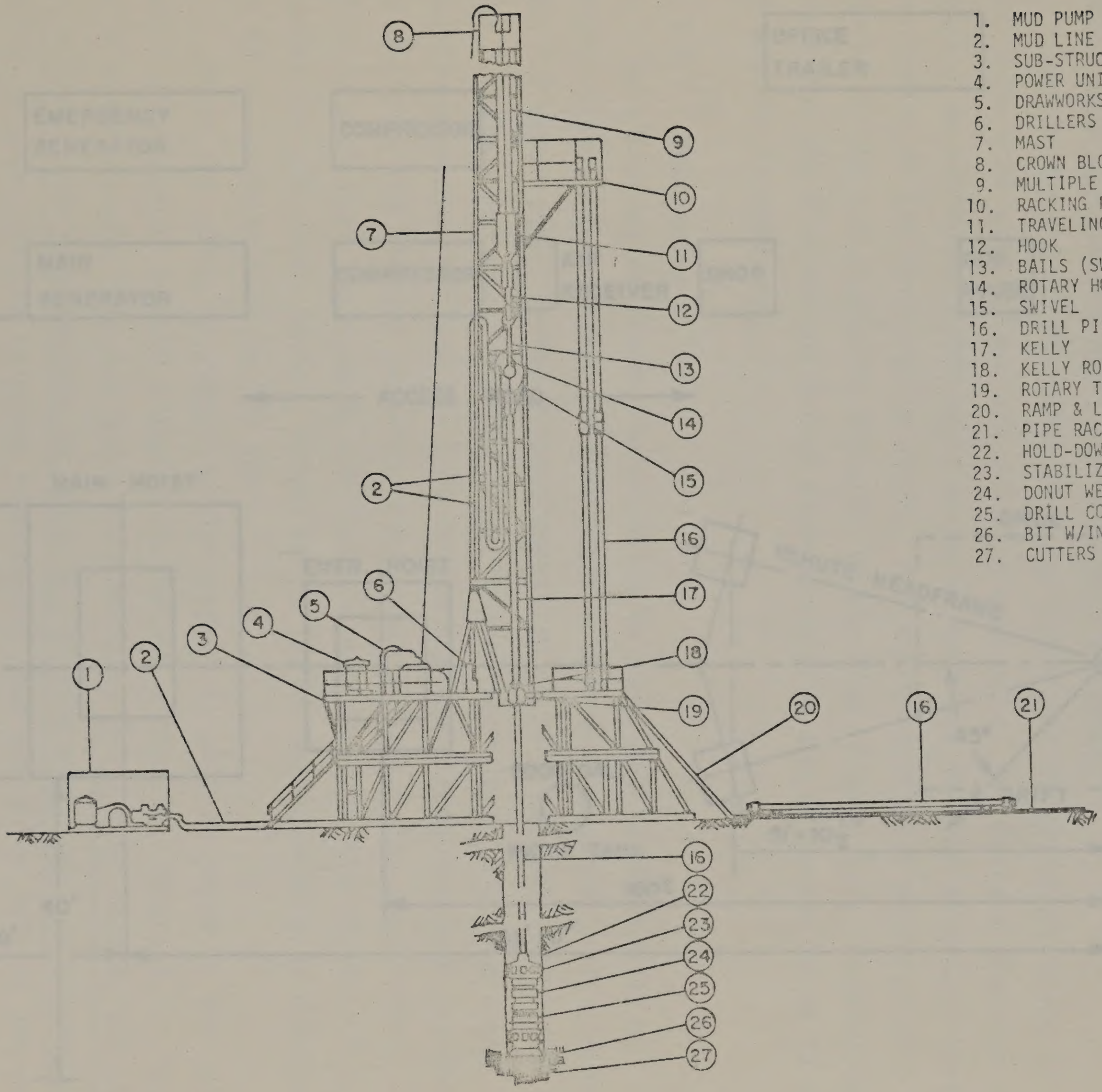


Figure 4.8 Cross Section of Typical Skip Pocket and Surge Bin



1. MUD PUMP & TANK
2. MUD LINE
3. SUB-STRUCTURE
4. POWER UNIT FOR DRAWBACKS
5. DRAWWORKS
6. DRILLERS CONTROL CONSOLE
7. MAST
8. CROWN BLOCK
9. MULTIPLE CABLES (TRAVELING BLOCK)
10. RACKING PLATFORM
11. TRAVELING BLOCK
12. HOOK
13. BAILS (SWIVEL)
14. ROTARY HOSE (SWIVEL GOOSE NECK)
15. SWIVEL
16. DRILL PIPE
17. KELLY
18. KELLY ROLLER BUSHING
19. ROTARY TABLE (KELLY DRIVE)
20. RAMP & LADDER
21. PIPE RACK
22. HOLD-DOWN CLAMP
23. STABILIZER
24. DONUT WEIGHTS
25. DRILL COLLAR STOOL
26. BIT W/INTEGRAL ROLLERS
27. CUTTERS (REMOVABLE)

Figure 4.9 Typical Large Diameter Shaft Drilling Rig

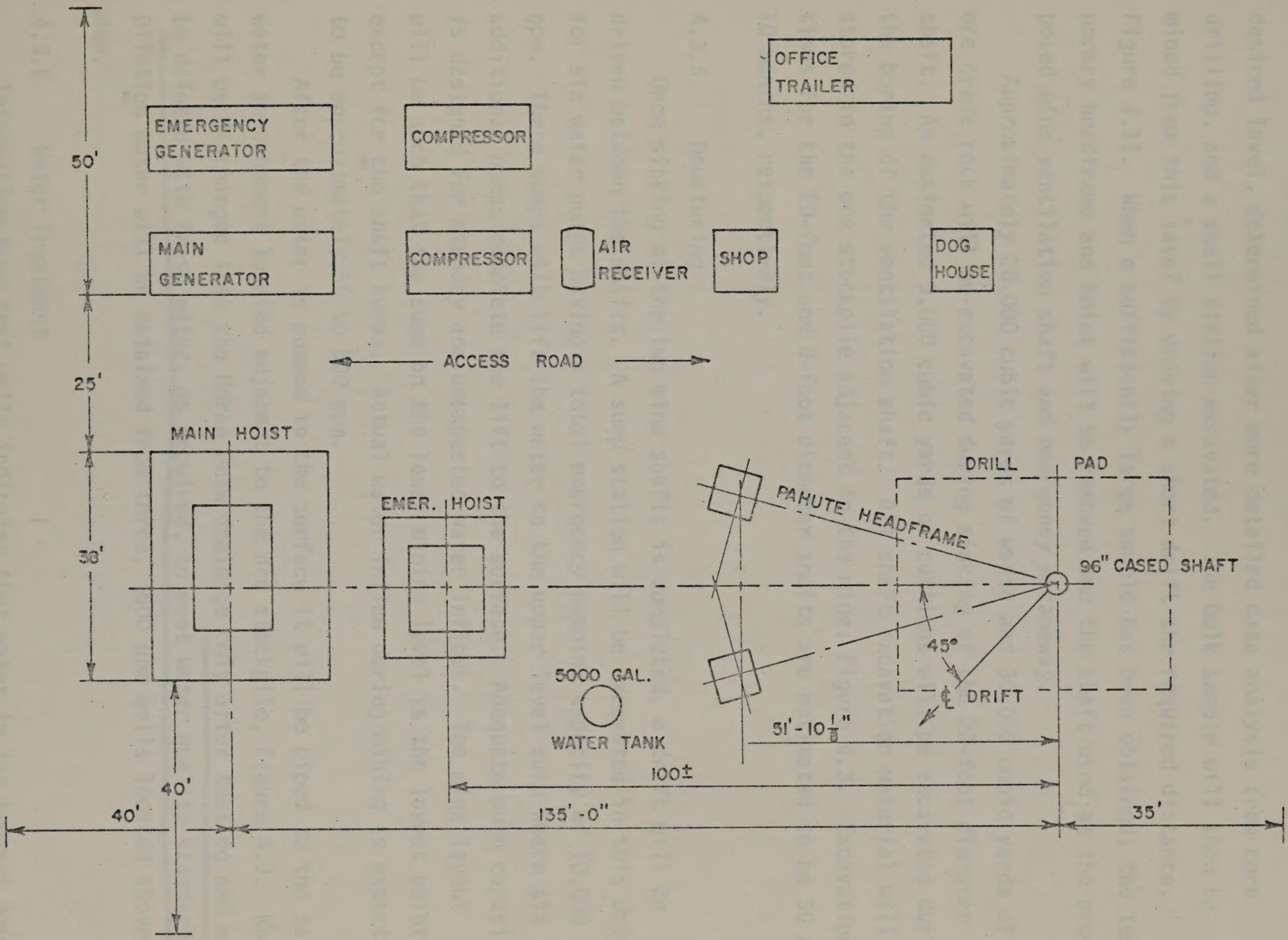


Figure 4.10 Proposed Surface Layout of Shaft Boring Equipment

desired level, determined after more detailed data analysis from core drilling, and a small station excavated. The bulk sample will then be mined from this level by driving a short drift the required distance, Figure 4.11. When a sufficiently large sample has been obtained, the temporary headframe and hoist will be removed and the shaft used as the proposed mine ventilation shaft and emergency escapeway.

Approximately 20,000 cubic yards of waste and 30,000 cubic yards of ore grade rock will be excavated during sinking of the 20-foot diameter shaft. An estimated 9,000 cubic yards of cuttings will be excavated during the boring of the ventilation shaft. All shaft excavation material will be stored in the ore stockpile adjacent to the mine, Figure 4.3. Excavation times for the 20-foot and 8-foot diameter shafts are estimated to be 30 and 10 months, respectively.

4.3.5 Dewatering

Once sinking of the two mine shafts is completed, a drift will be driven between the shafts. A sump station will be excavated in this drift for six water pumps having a total emergency pumping capacity of 10,000 gpm. These pumps will lift the water to the upper level sump where six additional pumps complete the lift to the surface. Adequate pump capacity is designed for standby and unexpected water inflows. The mine layout will be such that the sump on the lower mining level is the lowest point, except for the shaft sumps. Actual water inflow during mining is expected to be approximately 50 to 500 gpm.

~ 6K hp total

After the water is pumped to the surface it will be piped to the saline water impoundment located adjacent to the ore stockpile, Figure 4.3. Water will be discharged into the Horse Draw drainage only after testing and will be diluted with fresh water, as required, to meet water quality standards. Dilution water will be obtained from three, 600 gpm wells located above the dam.

4.3.6 Water Treatment

Information from test wells indicates that water in the bedrock aquifers is of fair quality above the saline zone, Figure 3.9. Water in fractures

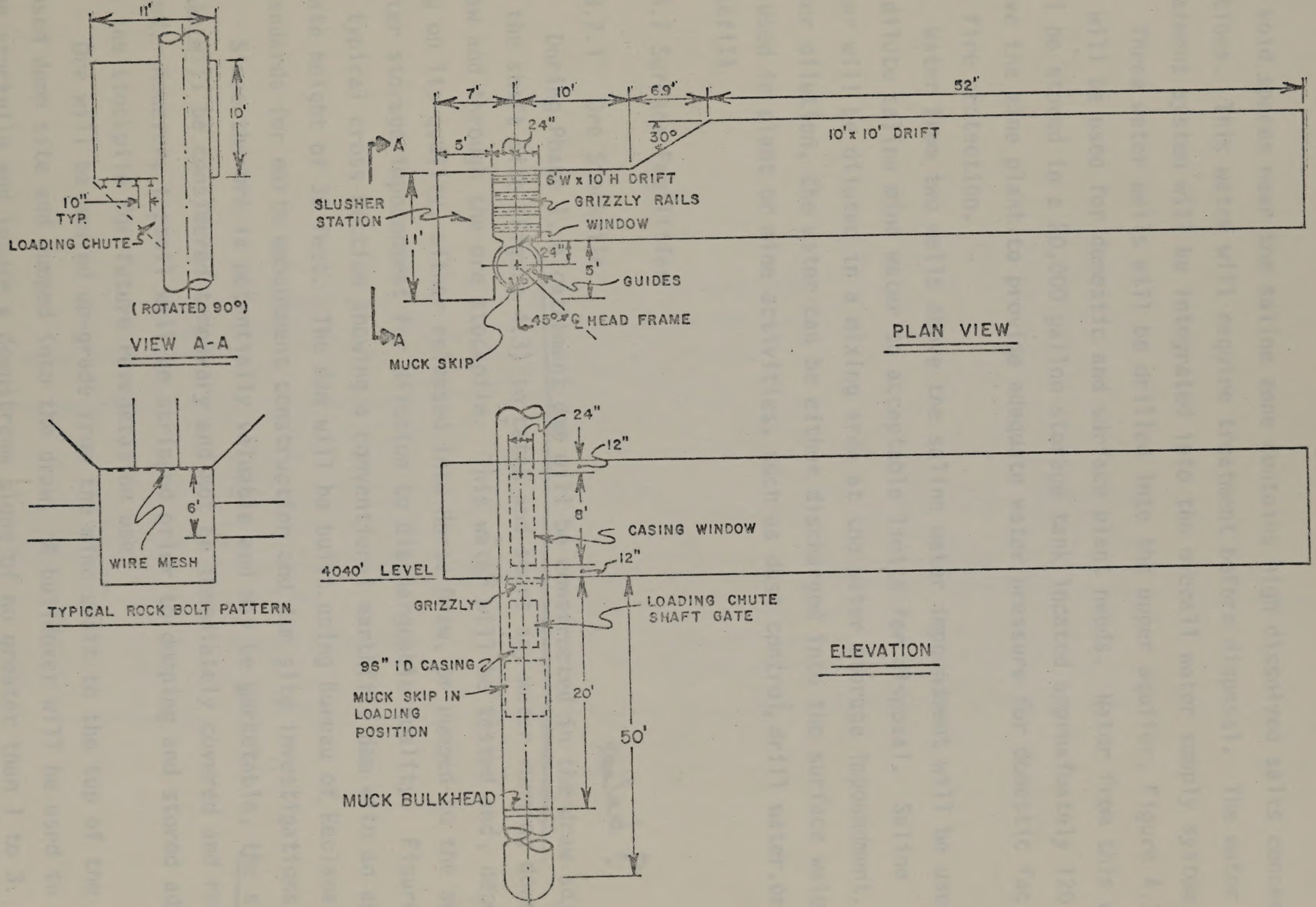


Figure 4.11 Proposed Bulk Sample Level Layout

and void spaces near the saline zone contains high dissolved salts concentrations. This water will require treatment before disposal. The water treatment system will be integrated into the overall water supply system.

Three water wells will be drilled into the upper aquifer, Figure 4.3. One will be used for domestic and surface plant needs. Water from this well will be stored in a 20,000 gallon storage tank located approximately 120 feet above the mine plant to provide adequate water pressure for domestic facilities and fire protection.

Water from two wells above the saline water impoundment will be used to dilute saline mine water to acceptable limits for disposal. Saline water will be diluted in a mixing area at the water storage impoundment. After dilution, the water can be either discharged into the surface water system or used in plant or mine activities, such as dust control, drill water, or mine backfill

4.3.7 Surface Facilities

4.3.7.1 Ore Stockpile

sealed ?

During Phase I, a catchment dam will be constructed in the draw adjacent to the shaft site (Figure 4.3) to catch and store any water running down the draw and through the ore stockpile. This water will be tested and, depending on its quality, either released into Horse Draw, or pumped to the saline water storage impoundment for dilution to dischargeable quality. Figure 4.12 is typical cross section showing a conventional earthfill dam with an approximate height of 30 feet. The dam will be built using Bureau of Reclamation standards for earth embankment construction and dam site investigations.

sealed ?.

Since the ore is potentially valuable and may be marketable, the stockpile will be considered temporary and not be immediately covered and revegetated. However, topsoil will be stripped prior to dumping and stored adjacent to the stockpile for future revegetation use.

Ore will be hauled up-grade from the mine shaft to the top of the proposed dump site and dumped into the draw. A bulldozer will be used to grade the stockpile and insure a downstream slope of no greater than 1 to 3. The stockpile will be gradually extended down the draw until the toe is

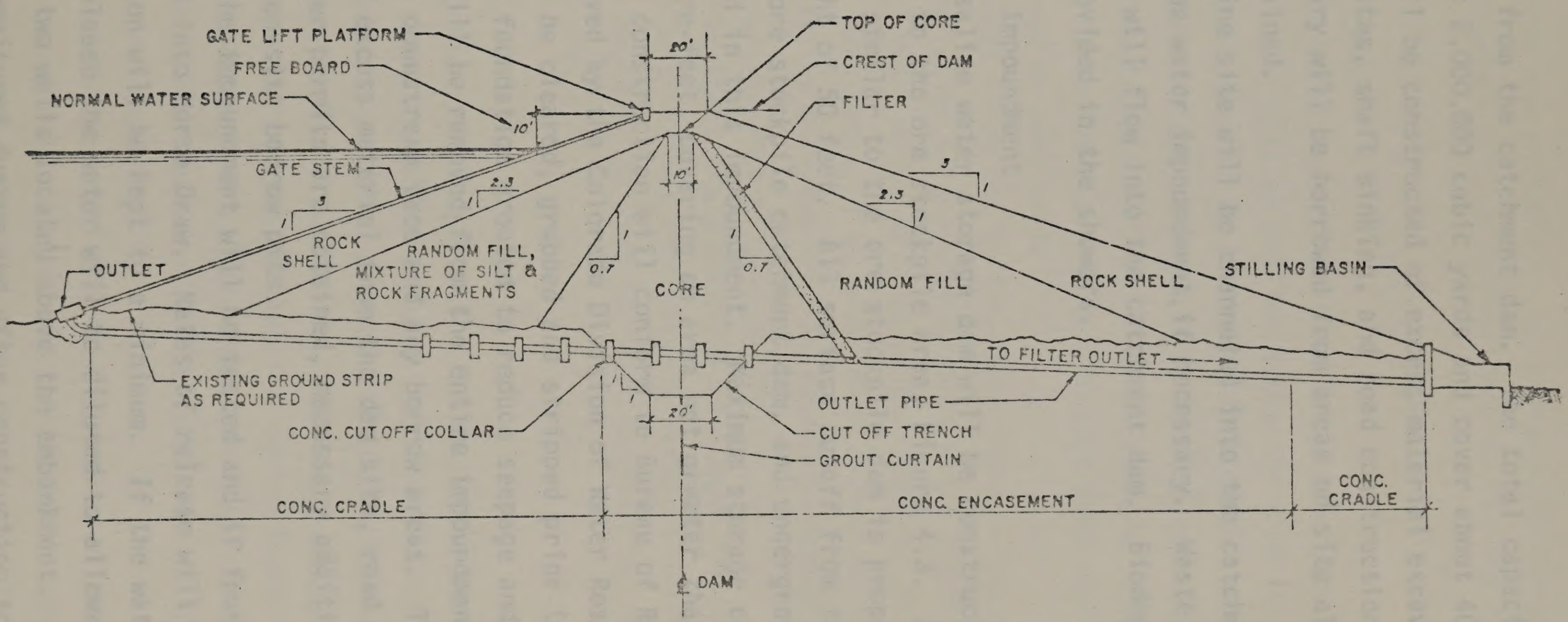


Figure 4.12 Cross Section of Typical Earth Fill Dam

approximately 100 feet from the catchment dam. The total capacity of the stockpile will be about 2,000,000 cubic yards and cover about 40 acres.

The embankment will be constructed of excess material excavated from the dam sites, shaft sites, shaft sinking, and road construction. Additional material, if necessary will be borrowed from areas on site after the proper permits are obtained.

Runoff from the mine site will be channeled into the catchment area and pumped to the saline water impoundment, if necessary. Waste water from changehouse facilities will flow into the catchment dam. Biodegradable soap and shampoo will be provided in the showers.

4.3.7.2 Saline Water Impoundment

During Phase I a saline water storage dam will be constructed in the draw east and adjacent to the ore stockpile area, Figure 4.3. Earthfill with clay-core construction similar to the ore stockpile dam is proposed, with a maximum estimated height of 50 feet. All surface runoff from the mine site, saline water from the ore stockpile catchment dam, and underground mine drainage will be stored in this impoundment. Maximum storage capacity will be approximately 80 acre-feet, covering an area not greater than about eight acres. Dam design and construction will conform to Bureau of Reclamation standards and be approved by the Colorado Division of Water Resources.

The dam site will be cleared, grubbed and stripped prior to construction and, if necessary, the foundation grouted to reduce seepage and uplift pressures. All top soil will be removed from the entire impoundment area and used to revegetate the downstream face and any borrow areas. The embankment will be constructed of excess material from the dam site, road cuts and shaft site. Once proper permits are obtained, necessary additional material will be obtained from on-site borrow pits.

Saline water in the impoundment will be tested and if found to be of good quality, released into Horse Draw. Rates of release will be controlled so that possible erosion will be kept to a minimum. If the water quality is unacceptable for release the water will be diluted to allowable standards by potable water from two wells located above the embankment.

The dam will be monitored during and after construction to ensure that

design and safety criteria are satisfied. Instrumentation systems will be installed to measure movements and earth pressures in the dam and its foundation.

4.3.7.3 Potable Water Wells

(monitoring & observation?)

Three potable water wells for use in the mine plant, underground mine, and dilution of saline water will be drilled above the mine site, Figure 4.3. The wells will be approximately 12 to 16 inches in diameter and drilled to the base of the "A" Groove. Initially the well located near the water storage tank will be pumped continuously. Maximum pumping rates are expected to be no greater than 600 gpm. A turbine-type pump with a 130 to 150-hp motor will be used on each well.

The two wells located above the saline water storage impoundment will be used primarily for dilution of any poor quality water pumped from the mine or catchment dam. Fresh water will be pumped from the wells into a mixing basin below the dam, where it is mixed with saline water coming from the dam Wells will be operated only as needed to reduce water usage. Pipe from the wells to mixing area will be buried.

Any water needed for spent shale backfill will most likely come from the saline water impoundment except when make-up water is needed. In addition, saline water may also be used for dust suppression if the amount of dissolved solids is low.

4.3.7.4 Power

The shaft sinking and development phases of the pilot mine facility will be operated with temporary electric power supplied by two 700-kw generators. During Phases I and II a permanent 5 to 10,000-kva power substation will be installed by White River Electric to supply the necessary 200,000 kw/day required to operate the mine during Phase IV. The substation will be surrounded by a locked, deer and livestock-proof fence, built to keep out unauthorized personnel. Estimated surface equipment power requirements are shown in Table 4.3.

The power corridor will parallel the mine access road, Figure 4.3, and bring power to a site substation. H-Frame, two-pole power poles, as shown in Figure 4.13, provide raptor protection and will be used exclusively for

Table 4.3 Surface Power Requirements

Item	No. Units	Hp	KW	Operating Hrs/Day	Total KW
Production Hoist	2	1,000	746	10	14,900
Service Hoist	1	600	450	10	4,500
Primary Fan	1	430	320	24	7,600
Changehouse/Office	1	--	200	10	2,000
Machine Shop	1	--	100	10	1,000
Miscellaneous	1	--	500	10	5,000
				Total	35,000

pumps

additional KW

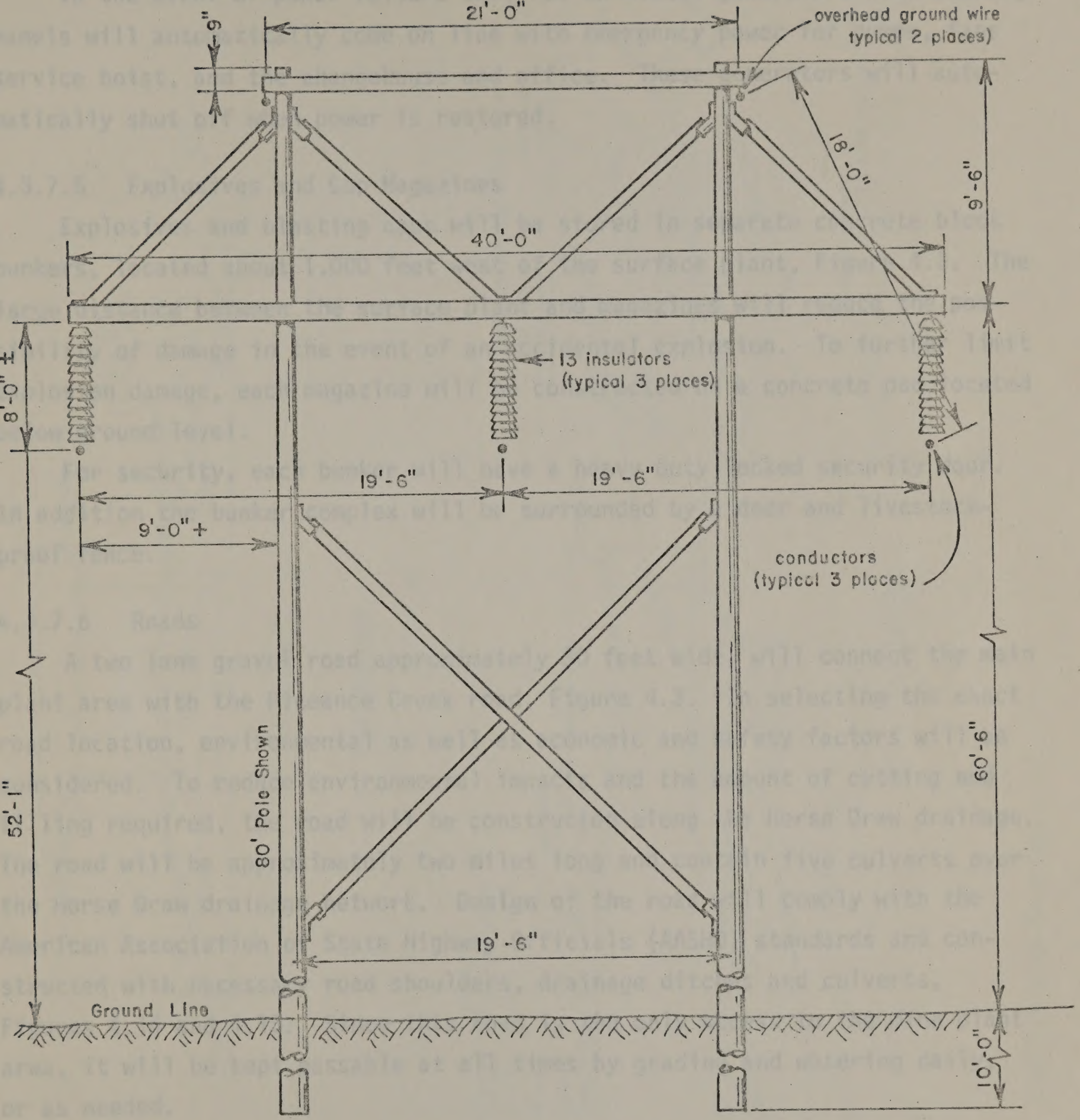


Figure 4.13 Typical High Voltage Power Pole Arrangement (Raptor Proof)

the power line.

In the event of power failure two, 700-kw diesel generators with sensing panels will automatically come on line with emergency power for pumps, fans service hoist, and the changehouse and office. These generators will automatically shut off when power is restored.

4.3.7.5 Explosives and Cap Magazines

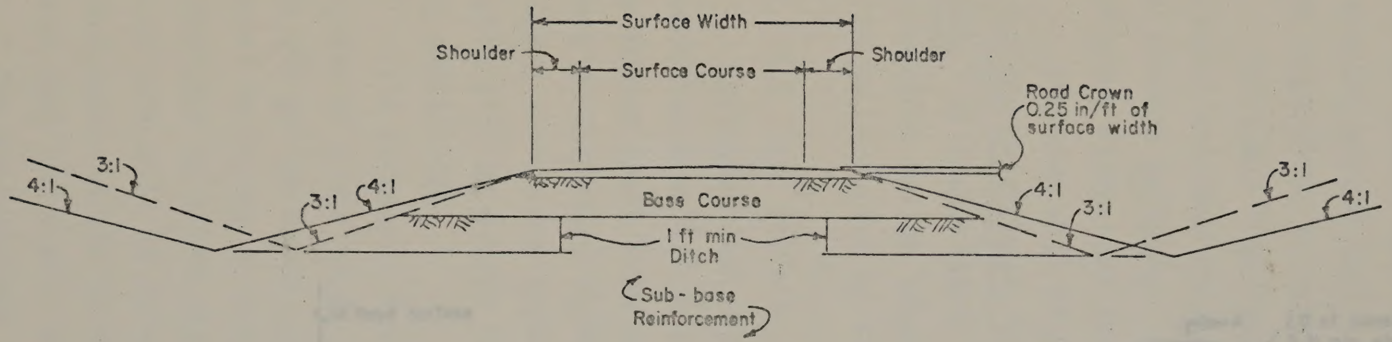
Explosives and blasting caps will be stored in separate concrete block bunkers, located about 1,000 feet west of the surface plant, Figure 4.3. The large distance between the surface plant and magazines will reduce the possibility of damage in the event of an accidental explosion. To further limit explosion damage, each magazine will be constructed on a concrete pad located below ground level.

For security, each bunker will have a heavy duty locked security door. In addition the bunker complex will be surrounded by a deer and livestock-proof fence.

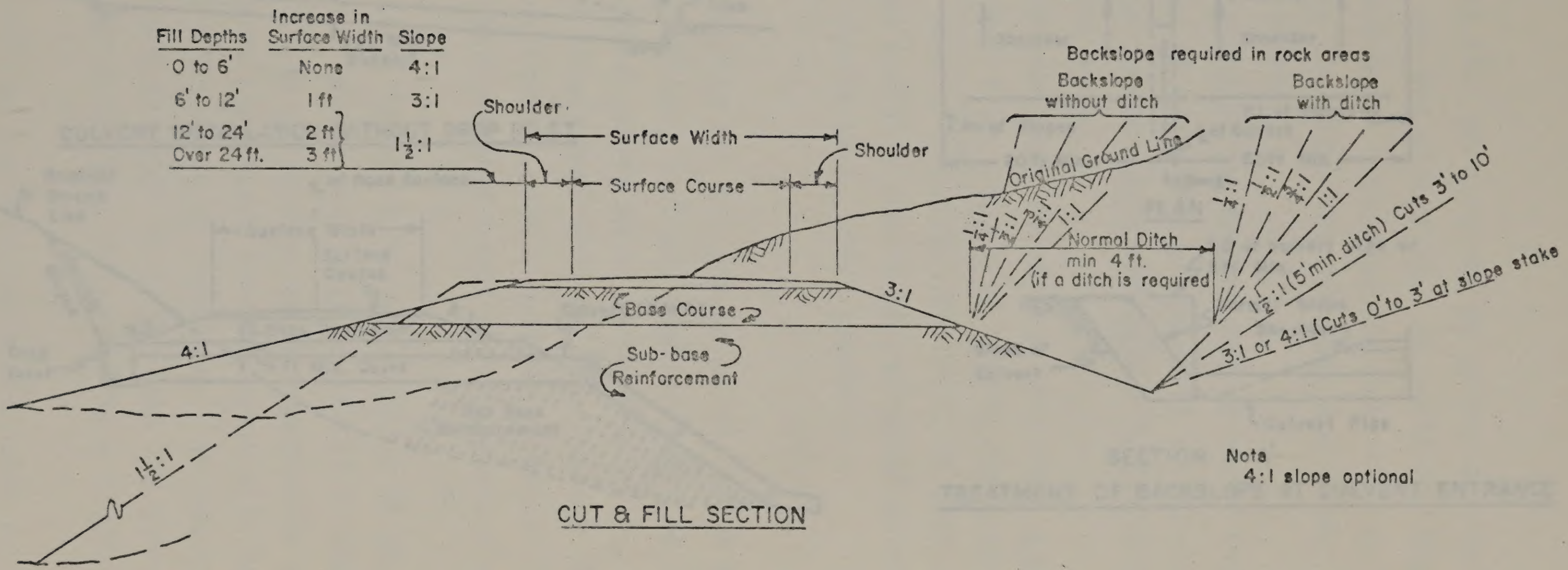
4.3.7.6 Roads

A two lane gravel road approximately 30 feet wide, will connect the main plant area with the Piceance Creek road, Figure 4.3. In selecting the exact road location, environmental as well as economic and safety factors will be considered. To reduce environmental impacts and the amount of cutting and filling required, the road will be constructed along the Horse Draw drainage. The road will be approximately two miles long and contain five culverts over the Horse Draw drainage network. Design of the road will comply with the American Association of State Highway Officials (AASHO) standards and constructed with necessary road shoulders, drainage ditches and culverts, Figures 4.14 and 4.15. Since this road is the only access to the mine plant area, it will be kept passable at all times by grading and watering daily, or as needed.

A second road from the surface plant to the ore stockpile will be constructed as a single lane road, designed according to AASHO standards. The road, used for off-highway trucks, will be equipped with safety berms and run-outs on downgrades. Turnouts will be provided as needed for truck passing. This road will be watered to minimize dust generation.



FILL SECTION



Fill Depths	Increase in Surface Width	Slope
0 to 6'	None	4:1
6' to 12'	1 ft	3:1
12' to 24'	2 ft	$1\frac{1}{2}$:1
Over 24 ft.	3 ft	

Note
4:1 slope optional

CUT & FILL SECTION

Figure 4.14 Typical Road Sections

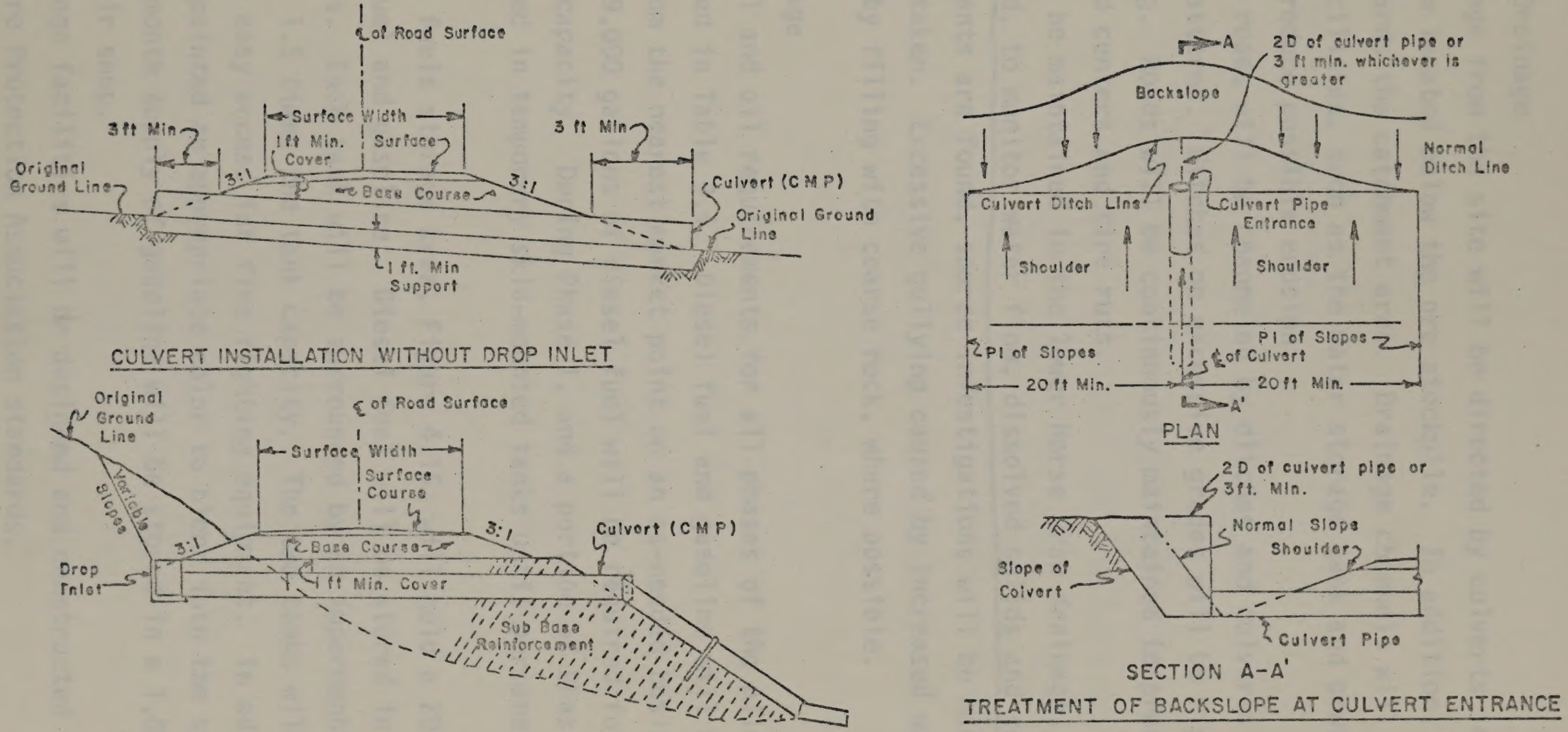


Figure 4.15 Typical Culvert Installations

4.3.7.7 Surface Drainage

Surface drainage from the site will be directed by culverts into the water catchment dam located below the ore stockpile. In addition, the site will be graded towards the catchment area. Drainage channels will be constructed around facilities, such as the water storage tank and powder and cap magazines, to reduce possible erosion.

Drainage from roads will be channeled by ditches and culverts into the natural drainage patterns. Ditches on excessive grades will be rip-rapped to prevent gullying. Roads will be continuously maintained to prevent gullying along road centers and tire ruts.

Stations will be maintained in the lower Horse Draw drainage, near Piceance Creek road, to monitor water flow, dissolved solids and contaminants. If contaminants are found, source investigations will be made and corrective action taken. Excessive gullying caused by increased water flow will be corrected by filling with coarse rock, where possible.

4.3.7.8 Fuel Storage

Estimated fuel and oil requirements for all phases of the pilot mine operation are listed in Table 4.4. Diesel fuel and gasoline will be supplied by tanker truck from the nearest market point on an as-needed basis. Each week an estimated 9,000 gallons of diesel fuel will be required for the designed production capacity. During Phase I, and a portion of Phase II, the fuels will be stored in temporary skid-mounted tanks until permanent storage is constructed.

The permanent fuels storage area, Figure 4.16, will hold a 20-day supply of diesel fuel and gasoline. Diesel fuel will be stored in two 18,000 gallon tanks. Each tank will be surrounded by an impermeable berm, equal in volume to 1.5 times the tank capacity. The two tanks will be separated to allow easy access for fire fighting equipment. In addition, each tank will be painted an appropriate color to blend into the surrounding landscape. A one month supply of gasoline will be stored in a 1,000 gallon tank near the repair shop.

The fuel storage facilities will be designed and constructed according to the National Fire Protection Association standards.

Table 4.4 Fuel and Oil Requirements

Product	Phase I	Phase II	Phase III	Phase IV	Phase V
Diesel Fuel	66,700	140,400	170,000	1,816,020	2,600
Gasoline	7,000	23,400	6,000	33,150	1,300
Motor Oil	1,500	3,280	3,540	37,000	80
Hydraulic Fluid	1,500	3,280	3,540	37,000	80

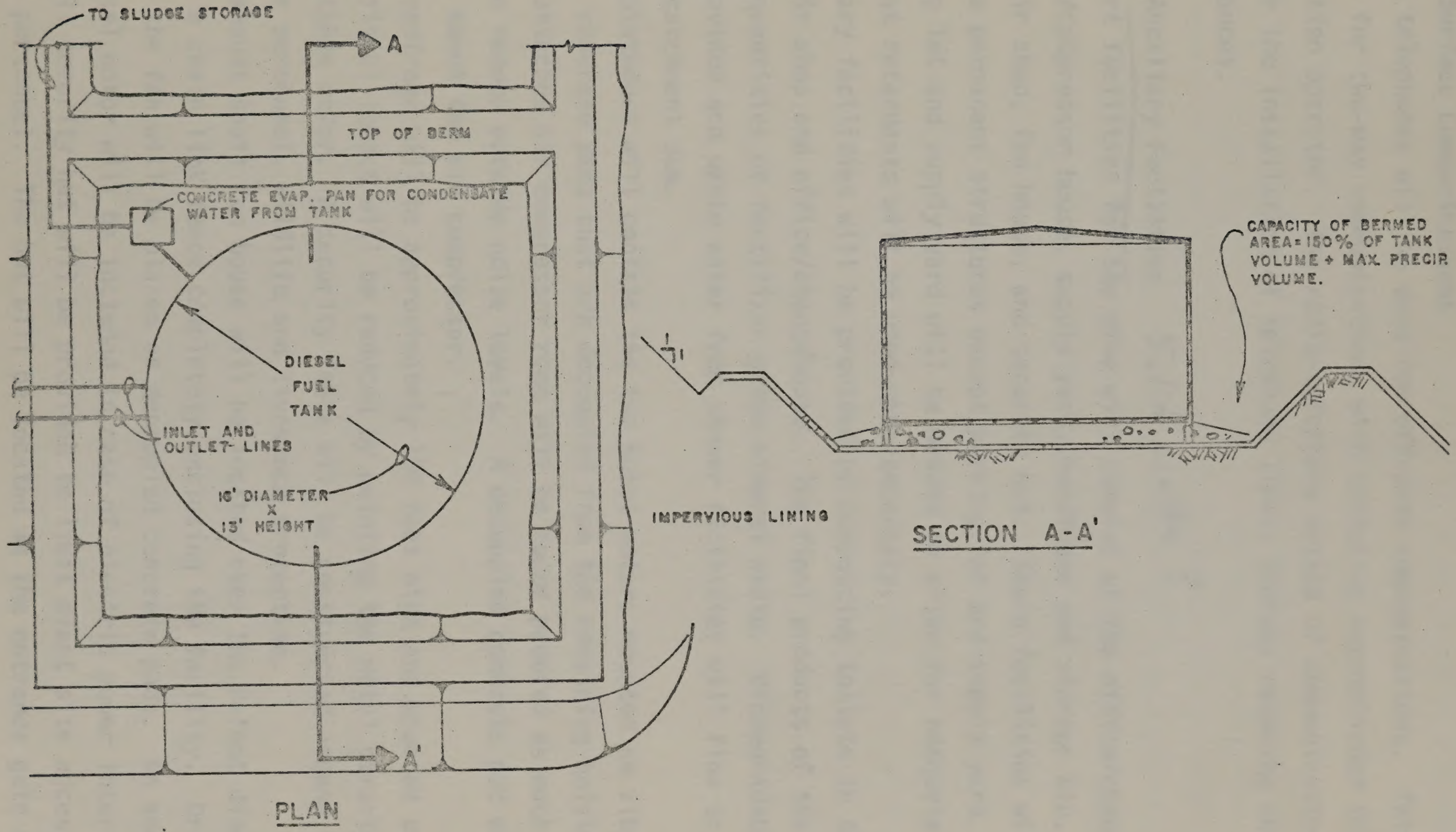

TO SLUDGE STORAGE
A
TOP OF BERM
CONCRETE EVAP. PAN FOR CONDENSATE WATER FROM TANK
DIESEL FUEL TANK
INLET AND OUTLET LINES
16' DIAMETER X 13' HEIGHT
A'
PLAN
IMPERVIOUS LINING
CAPACITY OF BERMED AREA = 150% OF TANK VOLUME + MAX. PRECIP. VOLUME.
3
1
SECTION A-A'

Figure 4.16 Typical Fuel Storage Tank

4.3.7.9 Surface Communications

Radio telephones will be used for off-site communications. This system will allow for two-way communication, with switching accomplished through a Grand Junction operator. The radio-telephone method of communication does not require the installation of telephone lines, thereby reducing environmental disturbances.

4.3.7.10 Ancillary Facilities

Solid waste ?

Support facilities for the mine will consist of the office/changehouse, hoisthouse/compressor house, supply yard, headframe and storage bin, warehouse/repair shop, fan house, and security hut. These facilities will be designed as permanent structures except parking lot and supply yard. Both the parking lot and supply yard will be graded to allow for adequate drainage and dust retardants will be used when necessary.

Sanitary facilities will be provided by composting toilets in the warehouse/repair shop and office/changehouse. The final products of the toilets are small quantities of fertilizer grade mineral waste. Biodegradable soaps will be provided and waste water from shower facilities will flow to the ore stockpile catchment dam.

The hoisthouse will contain the two hoist motors mounted on vibration resistant concrete pads that are decoupled from the remaining hoisthouse pad. The attached air compressor room will be sound proofed as much as possible to reduce outside noise levels. A decoupled concrete pad will also be used to mount the air compressor.

The headframe will be approximately 180 feet high and mounted on concrete footers. Visual impact will be reduced by painting the metal structural members a suitable color. A security fence will be constructed around the shaft opening for personnel, wildlife, and livestock protection.

The exhaust shaft fan house will be located over the 8-foot diameter shaft with a chain link fence completely enclosing the facility. Drive motors for the fan will be placed on decoupled concrete pads. An emergency backup diesel motor will be included in case of electric power interruption.

A small security hut will be provided to limit plant site access to authorized personnel. The hut will be located at the entrance gate on the

east side of the site. A security guard will be provided on a 24-hour basis.

4.3.7.11 Surface Equipment

Surface mobile equipment will be used mainly to stockpile mined rock and maintain roads and facilities. Estimated equipment requirements are listed in Table 4.5. Detailed design and engineering will provide the exact types and amounts of equipment needed, but should not vary appreciably from the original estimate. Stationary equipment will provide compressed air, ventilation, hoisting capability, and power to the mine.

Diesel-electric rear dump trucks with a 50-ton load capacity will haul mine-run rock to the ore stockpile. A motor grader will be used to maintain roads, ditches, and drainages. A 5,000 gallon capacity water truck will be used to water dirt and gravel roads to maintain air quality standards. A large bulldozer will be used for site construction, road construction, and maintenance of ore stockpile slopes.

Other mobile equipment will include a lubrication and fuel truck, pickup trucks, forklift, and an ambulance.

4.4 MINE DESIGN AND OPERATION

The mine design and operation presented in this section is preliminary and may be modified during the engineering part of Phases I and II. Equipment selection and manpower estimates are considered conservative and should take into account any later modifications.

4.4.1 Geologic and Engineering Data

Geologic and assay data from exploratory holes drilled on or near the site have given a reasonable idea of the geologic conditions in the proposed mine site. Because the primary purpose of the mine will be to determine the technical and economic feasibility of mining deep, thick oil shale, the first rich zone of oil shale was not chosen as a mining horizon. Figure 4.17 is a representative cross section through coreholes near the proposed site. The two mining levels are located in the base of the leached zone and in the R-3 zone. Overburden depth is approximately 1,100 feet to the top

Table 4.5 Surface Equipment List

Item	No. of Units	Description
Bulldozer	1	300 hp
Water Truck	1	5,000 gal. capacity
Diesel-electric Dump Truck	2	50 ton capacity
Forklift	1	1 ton capacity
Lubrication and Fuel Truck	1	2 ton
Pickup Truck	3	3/4 ton capacity
Road Grader	1	130 hp
Ambulance	1	2 Passenger Car
Air Compressor	1	2,000 cfm capacity
Primary Ventilation Fan	1	200,000 cfm capacity
Service Hoist	1	600 hp (450 kw)
Production Hoist	2	1,000 hp (746 kw)
Diesel Generators	2	700 kw
Pumps	3	112 kw

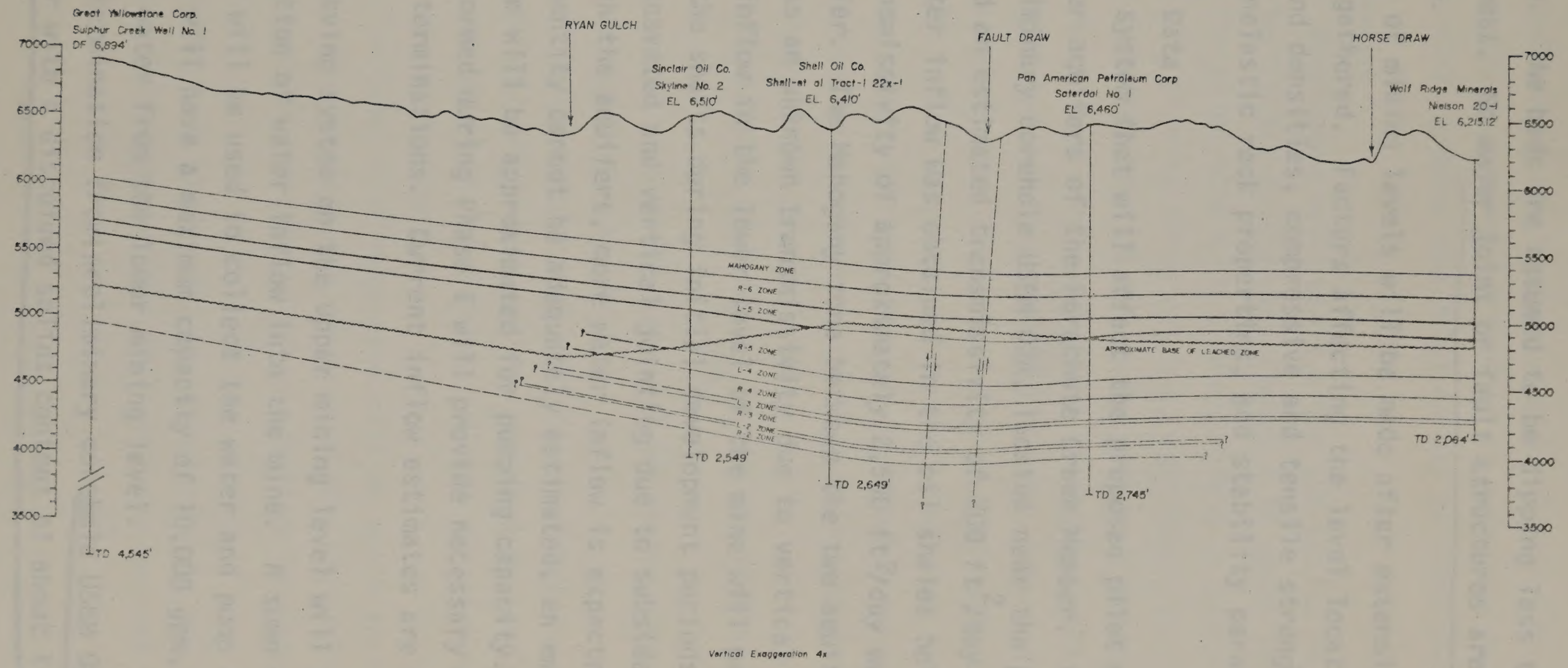


Figure 4.17 Geologic Cross Section Through Proposed Mine Site

of the Mahogany zone. The beds are assumed to be dipping less than one degree to the northwest. No major joint or fault structures are apparent in the proposed site.

Don't believe this! but many narrow joint systems ?

Exact selection of mining levels will be made after extensive geotechnical data has been gathered. Factors affecting the level location are fracture attitudes and densities, compressive and tensile strength of the oil shale, elastic and inelastic rock properties, and stability parameters.

4.4.2 Hydrologic Data

The groundwater system that will affect the proposed pilot mine consists of the Upper and Lower aquifers of the Parachute Creek Member. An aquifer pumping test in preliminary corehole USBM 02A, located near the proposed shaft sites, obtained an estimated transmissivity of 300 ft^2/day in the leached zone. No water inflow was obtained in the oil shales below the leached zone. A transmissivity of approximately 2,500 ft^2/day was obtained in the Upper aquifer. The Mahogany zone between the two aquifers may act as an aquatard and has an unknown transmissivity due to vertical jointing.

Expected water inflow in the lower level of the mine will probably come primarily from the shafts during initial development periods. However, as areas are excavated and vertical jointing due to subsidence effects extend through the aquifers, more water inflow is expected. Because the inflow quantity cannot be adequately estimated, an emergency capacity of 10,000 gpm will be approximated for pumping capacity. Additional water testing performed during Phase I will provide necessary data for sump and pump size determinations. Current inflow estimates are from 50 to 500 gpm.

Testing of the caving system on the upper mining level will probably produce the major portion of water inflow into the mine. A sump station located on this level will be used to collect the water and pump it to the surface. These pumps will have a maximum capacity of 10,000 gpm, however, they must also handle water from the lower mining level.

Water quality determination from preliminary corehole USBM 02A indicate relatively clean water with a dissolved solids content of about 1,100 mg/l.

This water could be disposed on the surface with no dilution to meet stream requirements. However, over a period of time it is estimated that the dissolved solids content will increase and dilution may be necessary.

4.4.3 Mine Development

Underground mine development will start after the shafts have been sunk and the surface facilities completed. Figure 4.18 shows the initial development phase of the pilot mine with a design based on gassy conditions. Development will begin by driving three entries, approximately 12 by 15 feet, a distance of about 1,100 feet through the shaft pillar. The two outside entries will be used for intake air, manways and re-supply, with the middle entry containing the isolated conveyor belt entry. Two other entries, also 12 by 15 feet, will be driven from the 8-foot diameter exhaust shaft a distance of about 1,900 feet. These two entries will be used for the return air and are located about 450 feet from the intake air entries.

During the period of mine development, lasting an estimated 200 work days, the following projects will be completed:

- A pumping station capable of handling 10,000 gpm of mine water will be built.
- A high voltage power substation room will be constructed near the 20-foot diameter shaft station.
- A maintenance shop and supply room will be excavated and constructed in the shaft pillar. This shop will be equipped to handle major maintenance problems that might arise. A room for storage of supplies and machine parts is included.
- Firing devices and explosive magazines will be built in the return air entry. The firing devices (electric or fuse caps) and explosives will be kept separate and located in an area free of hazardous conditions.
- A 36-inch conveyor belt drive will be installed near the 20-foot diameter shaft. The conveyor belt will be floor mounted and fire resistant.

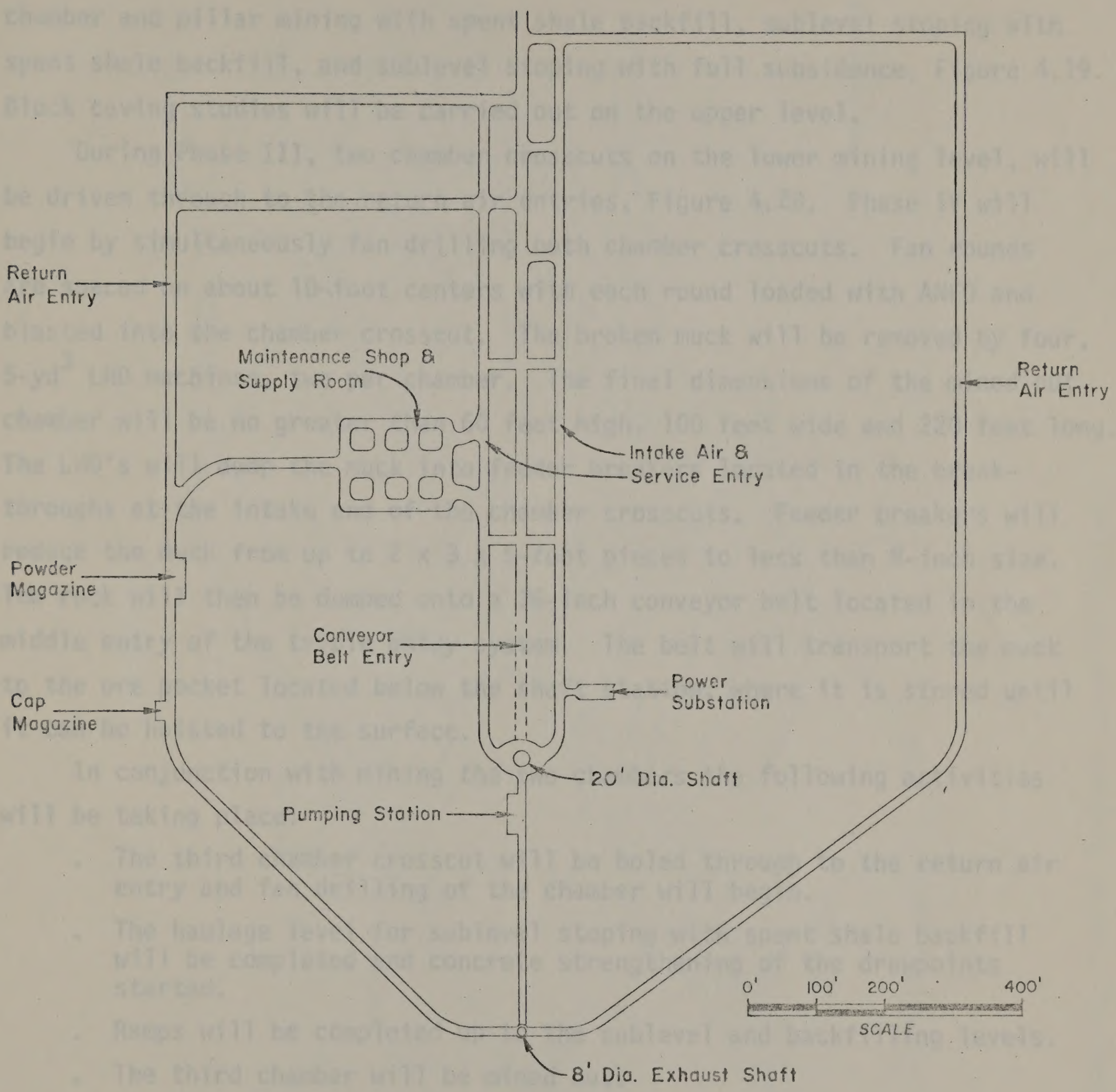


Figure 4.18 Plan View of Proposed Mine Development on Lower Mining Level

4.4.4 Mining Systems Testing

During the mine testing phase, four mining systems will be studied. Three mining methods will be tested on the lower mining level. They are, chamber and pillar mining with spent shale backfill, sublevel stoping with spent shale backfill, and sublevel stoping with full subsidence, Figure 4.19. Block caving studies will be carried out on the upper level.

During Phase III, two chamber crosscuts on the lower mining level, will be driven through to the return air entries, Figure 4.20. Phase IV will begin by simultaneously fan drilling both chamber crosscuts. Fan rounds are spaced on about 10-foot centers with each round loaded with ANFO and blasted into the chamber crosscut. The broken muck will be removed by four, 5-yd^3 LHD machines, two per chamber. The final dimensions of the mined out chamber will be no greater than 60 feet high, 100 feet wide and 220 feet long. The LHD's will dump the muck into feeder breakers located in the breakthroughs at the intake end of the chamber crosscuts. Feeder breakers will reduce the muck from up to 2 x 3 x 5-foot pieces to less than 8-inch size. The rock will then be dumped onto a 36-inch conveyor belt located in the middle entry of the triple entry system. The belt will transport the muck to the ore pocket located below the shaft station, where it is stored until it can be hoisted to the surface.

In conjunction with mining the two chambers the following activities will be taking place:

- The third chamber crosscut will be holed through to the return air entry and fan drilling of the chamber will begin.
- The haulage level for sublevel stoping with spent shale backfill will be completed and concrete strengthening of the drawpoints started.
- Ramps will be completed up to the sublevel and backfilling levels.
- The third chamber will be mined out.

After the above tasks are completed, mining of sublevel stoping with spent shale backfill will begin. A raise will be bored down from the sublevel to the haulage level to provide a free face for fan round blasting. Fan rounds will be drilled from the sublevel in a vertical circle, approximately on 10-foot centers. Each round will be loaded with explosive and sequentially

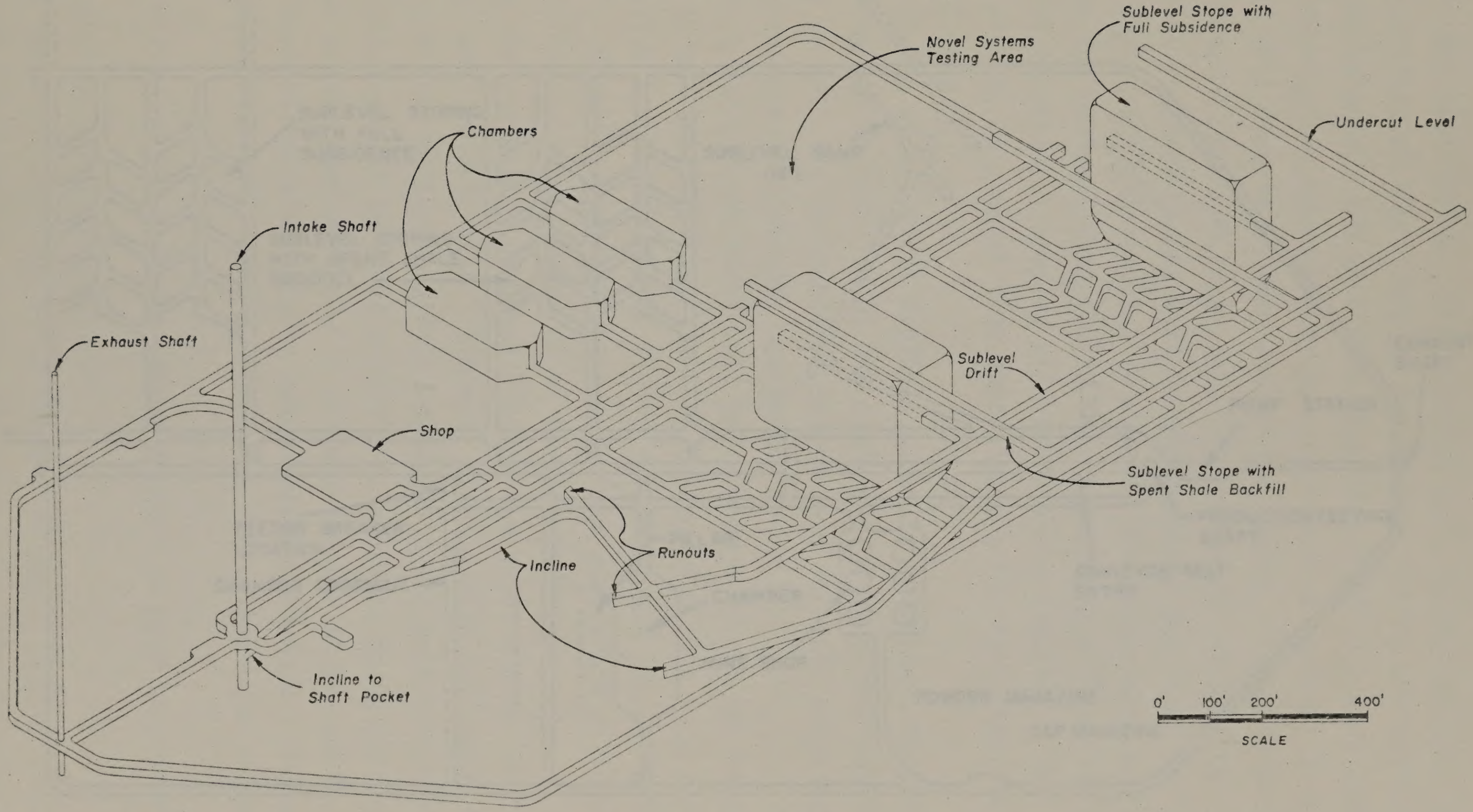


Figure 4.19 Isometric View of Proposed Lower Mining Level

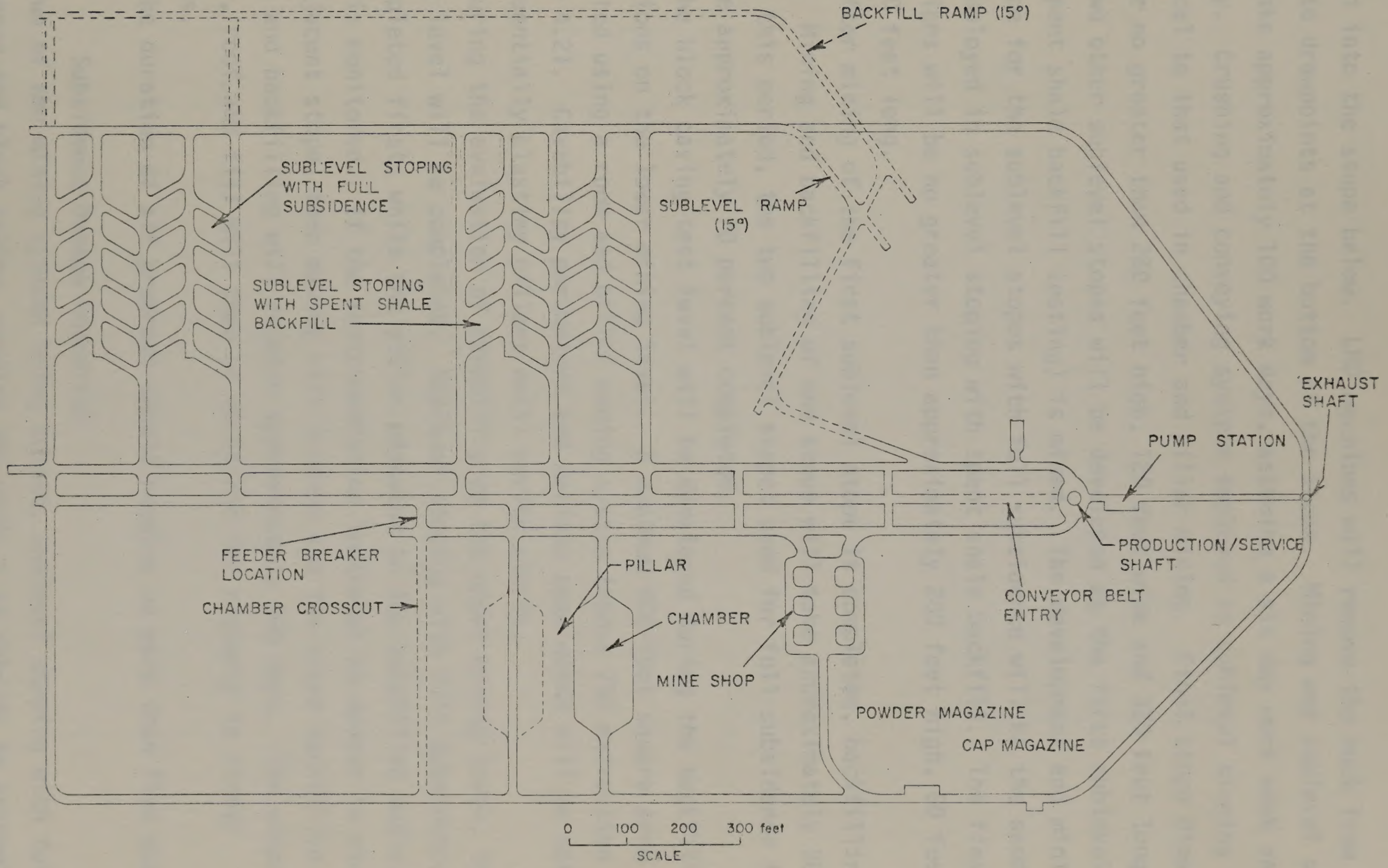


Figure 4.20 Plan View of Mined Lower Level

blasted into the stope below. LHD machines will remove the muck from the concrete drawpoints at the bottom of the stope. Mining one sublevel stope will take approximately 100 work days, assuming a six day work week and two shifts per day. Crushing and conveying systems employed in sublevel stoping will be identical to that used in chamber and pillar mining. Final stope dimensions will be no greater than 280 feet high, 120 feet wide and 320 feet long.

Two other sublevel stopes will be developed as the first sublevel stope (for spent shale backfill testing) is mined. The development and mining sequence for the sublevel stopes with full subsidence will be the same as that employed in sublevel stoping with spent shale backfill. The final stope dimensions will be no greater than approximately 280 feet high, 80 feet wide, and 320 feet long.

After mining of the first sublevel stope is completed, backfilling will begin. Mining and backfilling of one stope will take approximately 300 days. During this period, the two sublevel stopes used for full subsidence testing will be approximately 70 percent completed.

The block caving test level will be developed during the backfilling operations on the lower mining level. A maximum 400-foot square area will be excavated using a room and pillar mining system (about 75% extraction ratio), Figure 4.21. Cavability parameters and maximum span width will be determined by sequentially blasting pillars until caving starts.

During the evaluation of cavability on the upper mining level, the lower mining level will be completed. Sublevel stoping with full subsidence will be completed first, while the pillar adjacent to the backfilled sublevel stope is monitored. If the instrumentation indicates no danger in mining the adjacent stope, then mining will proceed and the stope backfilled. Mining and backfilling will require approximately 300 days. The stope pillar, roof, and fill will then be monitored for response to stress changes.

The duration of all programs should require no more than five years.

4.4.5 Subsidence Damage Potential

Two of the mining systems being tested, sublevel stoping with full subsidence and block caving, require the surface to subside to prevent

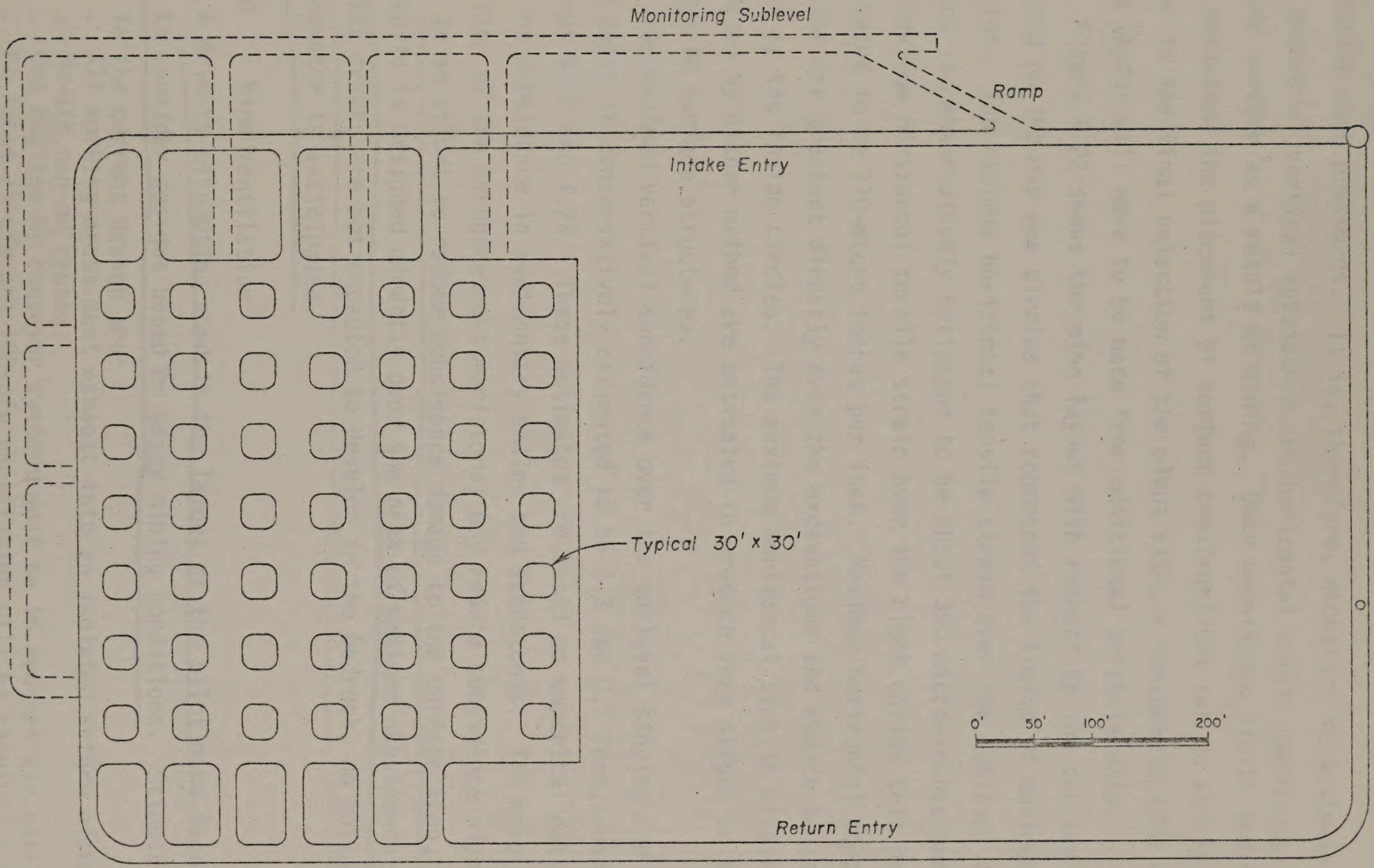


Figure 4.21 Plan View of Proposed Block Caving Level

excessive rock pressures. It is, therefore, necessary to estimate the potential vertical subsidence and horizontal strain magnitude on the surface as a result of mining. Once subsidence limits and magnitudes are estimated the placement of surface constructions can be safely made. Prior to the final selection of the plant site, a reasonable idea of the mine layout will have to be made from additional corehole data.

Figure 4.22 shows the mine layout with respect to the surface facilities. Plotted on the map are circles that represent the limits of maximum horizontal strains. The maximum horizontal tensile strain over the sublevel stoping method is conservatively estimated to be about 350 micro-inches per inch. The maximum horizontal tensile strain over the block caving test panel is estimated to be 170-micro inches per inch. Maximum horizontal compressive strains are greatest directly over the excavations and reduce to zero as shown by the inside circles. The maximum horizontal tensile strains produced by either method are estimated to produce very slight or negligible damage to surface structures.

The maximum vertical subsidence over the sublevel stoping and caving test panel is conservatively estimated to be 1.3 and 0.7 feet, respectively, Figures 4.23 and 4.24. These estimates are based on emperical data available on subsidence in sedimentary shales and sandstones. The more plastic behavior of the kerogenaceous marlstones may reduce subsidence significantly.

In an effort to reduce subsidence damage to the surface area, the ore stockpile is designed directly over the area of maximum subsidence. Because surface cracks are not expected to develop in the bedrock, no pollution of groundwater is anticipated.

4.4.6 Mine Ventilation

A primary assumption used in the layout of the pilot mine facility has been to consider designs based on gassy mining conditions. Stipulations used in the current design are:

- All working areas must exhaust into an isolated return airway.
- No air can be reused.
- Ore haulage by conveyor systems must be in neutral air entries.
- At least 75-cfm and 100-cfm ventilation will be required for each brake horsepower and man, respectively.
- Except during initial development, break-throughs will be made every 100 feet in intake air entries.

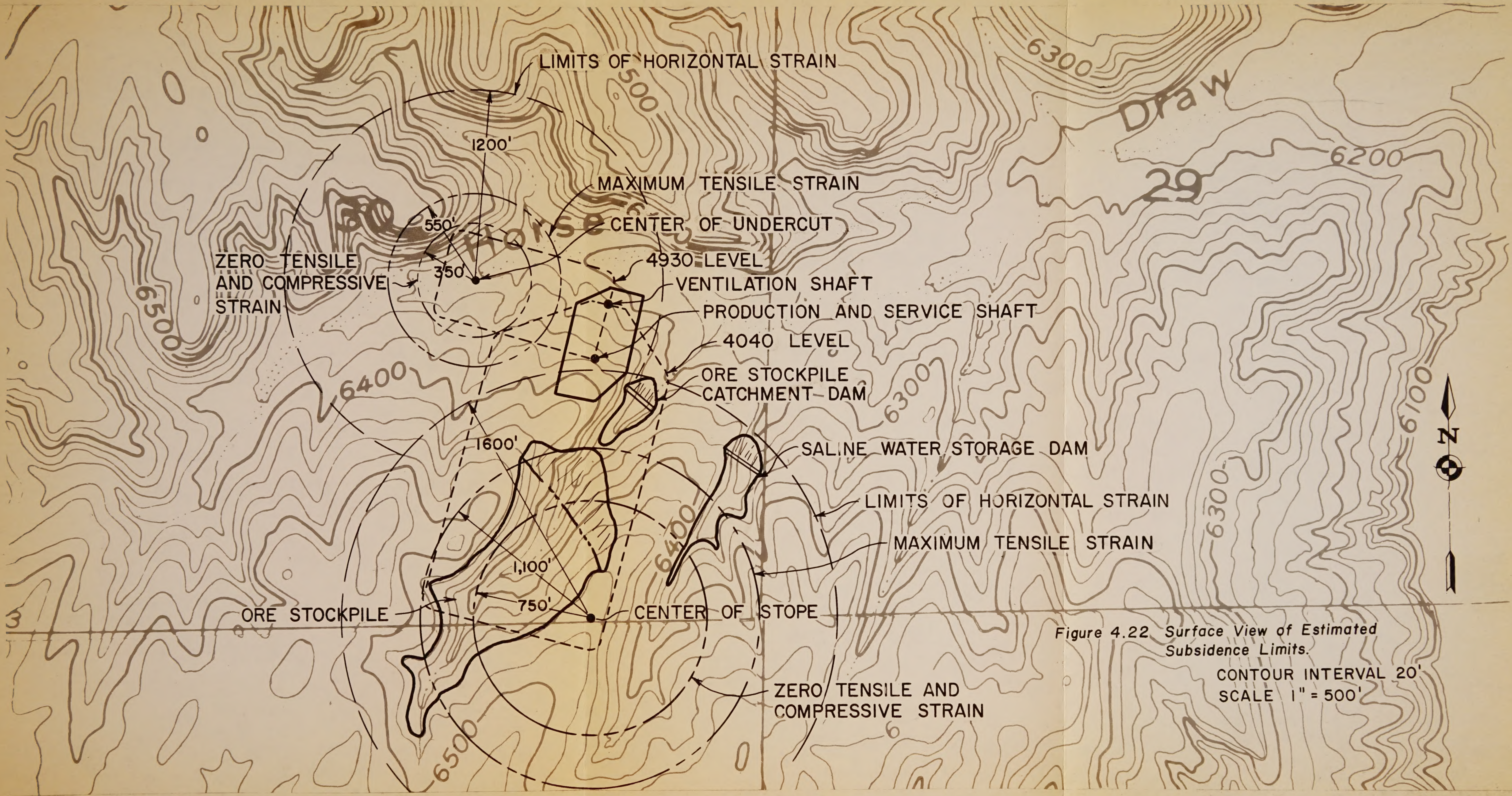


Figure 4.22. Surface View of Estimated Subsidence Limits.

CONTOUR INTERVAL 20'
SCALE 1" = 500'

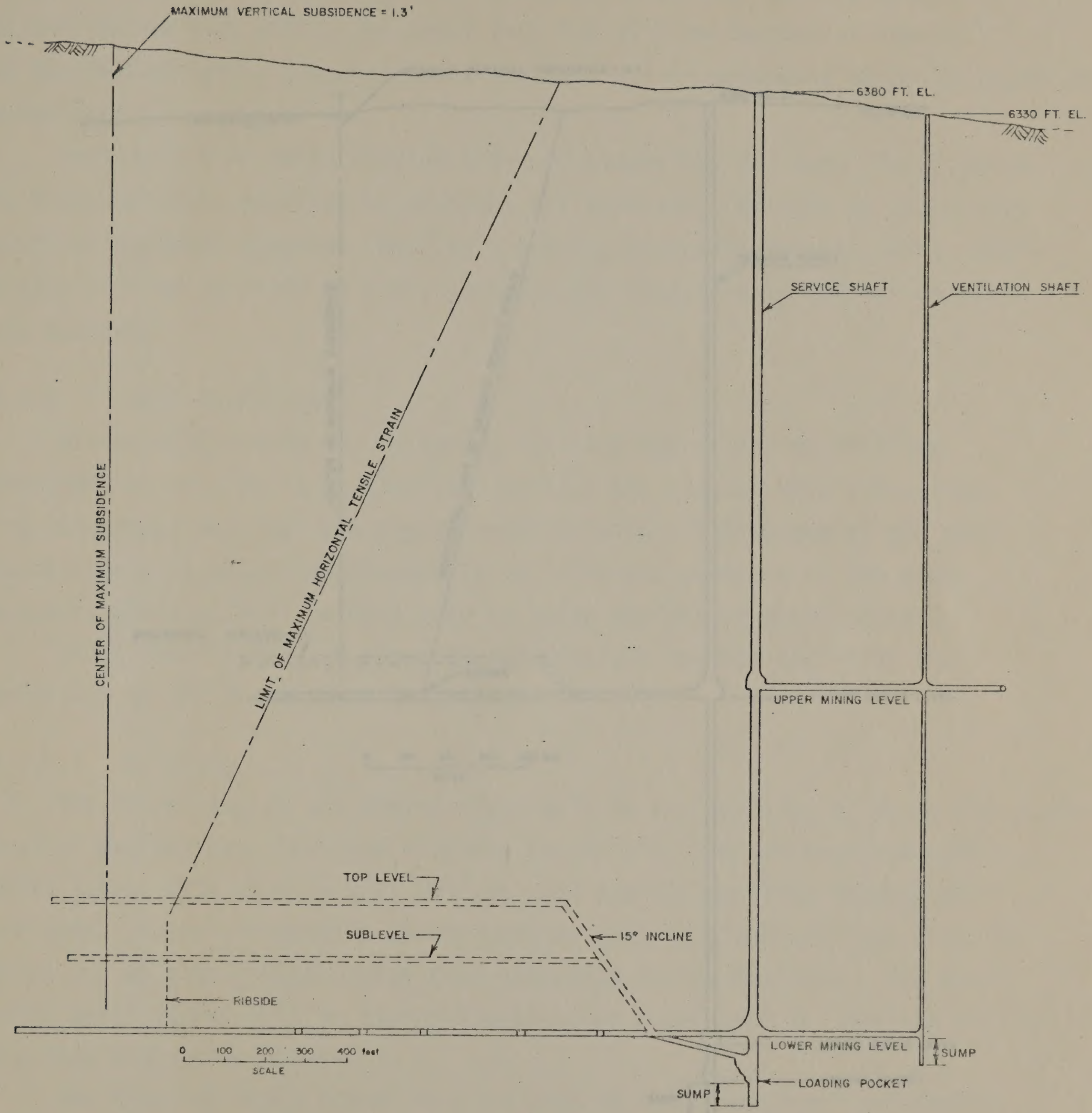


Figure 4.23 Vertical Section Through Proposed Mine Looking N75°W

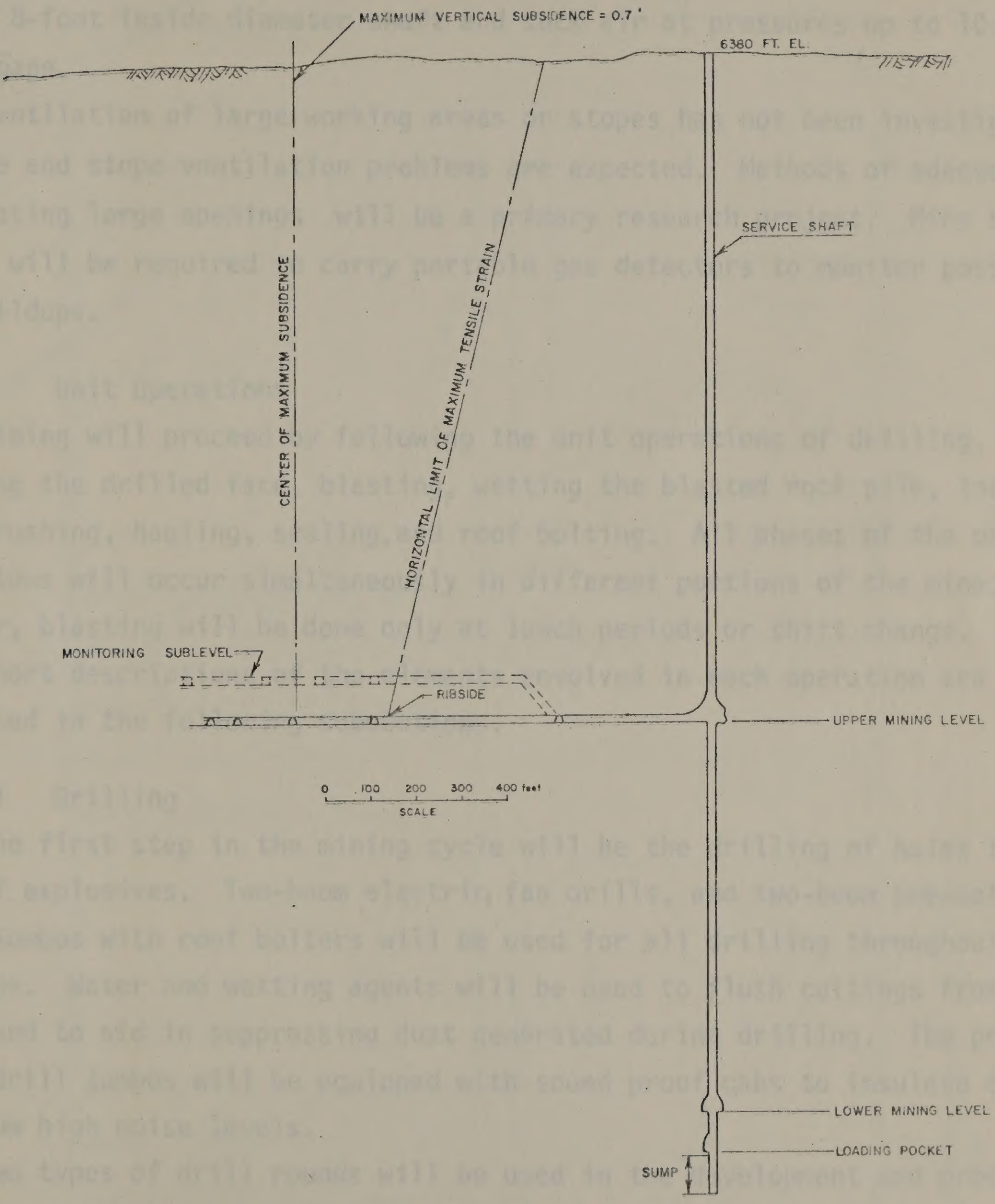


Figure 4.24 Vertical Section Through Proposed Mine Looking N15°E

The proposed ventilation network is shown in Figure 4.25 and illustrates a triple entry system. A total estimated flow rate of 200,000 cfm has been calculated, based on total equipment horsepower and men working underground during each shift. An axial vane fan will be located at the top of the 8-foot inside diameter shaft and suck air at pressures up to 10-inches of water gage.

Ventilation of large working areas or stopes has not been investigated to date and stope ventilation problems are expected. Methods of adequately ventilating large openings will be a primary research project. Mine supervisors will be required to carry portable gas detectors to monitor possible gas buildups.

4.4.7 Unit Operations

Mining will proceed by following the unit operations of drilling, charging the drilled face, blasting, wetting the blasted rock pile, loading, crushing, hauling, scaling,and roof bolting. All phases of the unit operations will occur simultaneously in different portions of the mine; however, blasting will be done only at lunch periods or shift change.

Short descriptions of the elements envolved in each operation are described in the following subsections.

4.4.7.1 Drilling

The first step in the mining cycle will be the drilling of holes for placement of explosives. Two-boom electric fan drills, and two-boom pneumatic drill jumbos with roof bolters will be used for all drilling throughout the mine. Water and wetting agents will be used to flush cuttings from the holes and to aid in suppressing dust generated during drilling. The pneumatic drill jumbos will be equipped with sound proof cabs to insulate drillers from high noise levels.

Two types of drill rounds will be used in the development and production phases of the mine. Two-boom face jumbos will be used for development headings and two-boom electric fan drills used for fan rounds. Typical drilling patterns are shown in Figure 4.26.

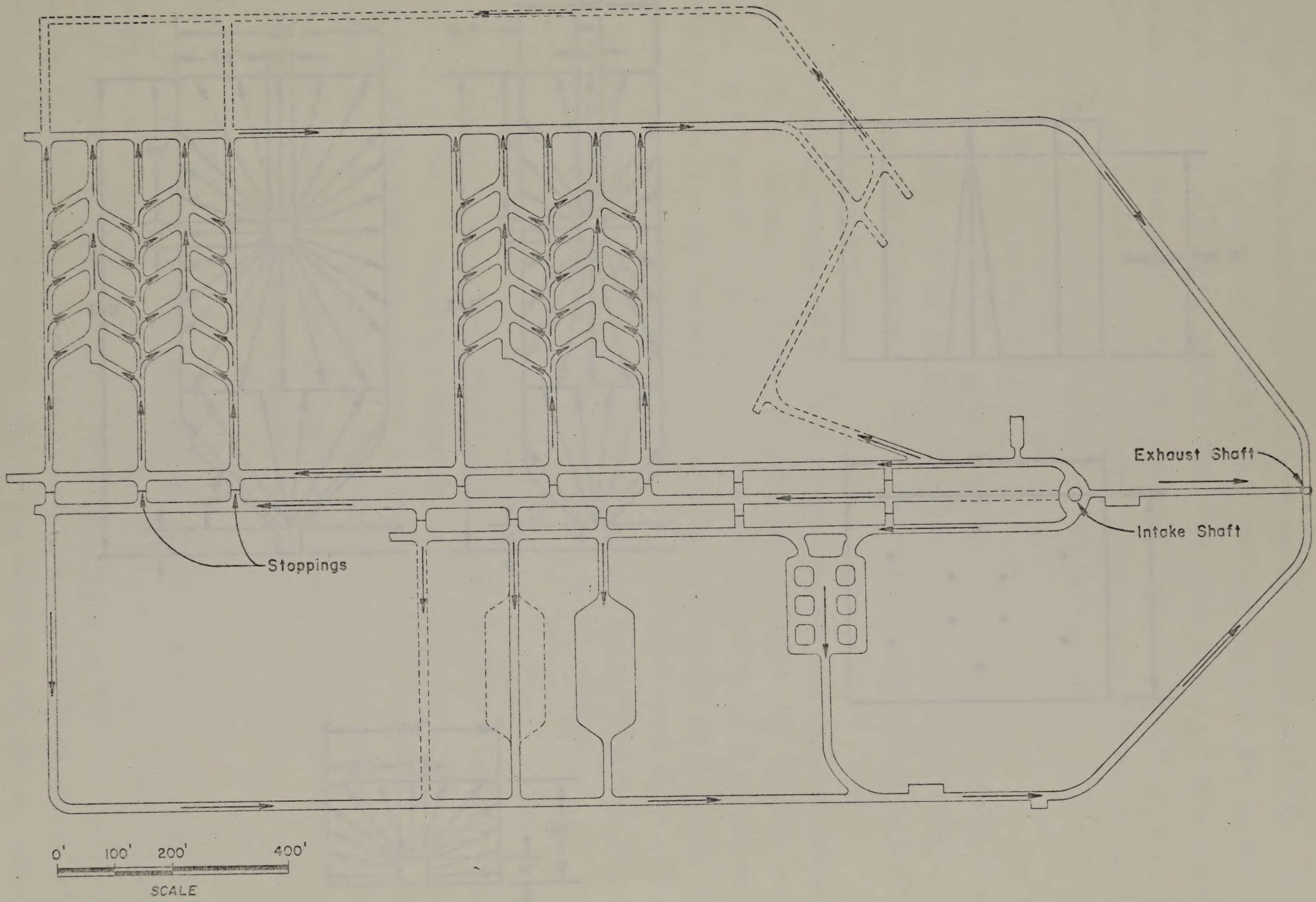


Figure 4.25 Proposed Ventilation Network, Lower Mining Level

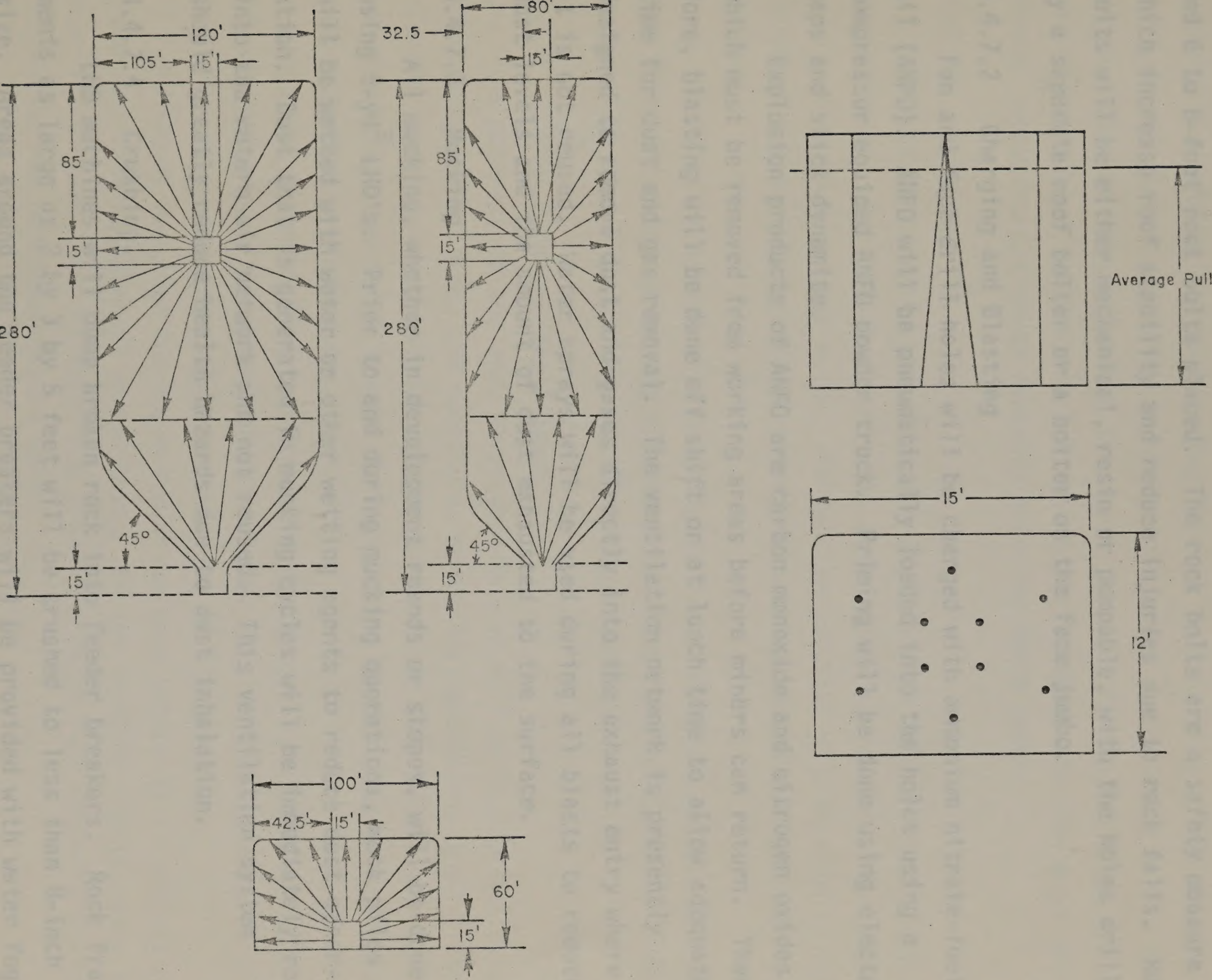


Figure 4.26 Typical Drilling Patterns

Roof bolting is an integral part of the development drilling. Prior to advancing in a recently mucked round, the back or roof will be drilled and 6 to 8-foot rock bolts placed. The rock bolts are a safety measure which increase roof stability and reduce injuries due to rock falls. Roof bolts will be either mechanical, resin or pumpable, with the holes drilled by a separate roof bolter or a bolter on the face jumbo.

4.4.7.2 Charging and Blasting

Fan and face drill holes will be charged with ammonium nitrate-fuel oil (ANFO). ANFO will be pneumatically loaded into the holes using a compressor equiped ANFO powder truck. Priming will be done using electric caps and stick dynamite.

Explosion products of ANFO are carbon monoxide and nitrogen oxides which must be removed from working areas before miners can return. Therefore, blasting will be done off shift or at lunch time to allow adequate time for dust and gas removal. The ventilation network is presently designed to remove dust and gases directly into the exhaust entry where it is not reused. Water sprays will be used during all blasts to reduce dust levels and the amount of dust exhausted to the surface.

4.4.7.3 Mucking

All mucking, whether in development rounds or stopes, will be done using 5-yd^3 LHD's. Prior to and during mucking operations, muck piles will be wetted with water or other wetting agents to reduce dust generation. Dust that is generated in mucking cycles will be immediately removed into the return air network and not reused. This ventilation system should greatly reduce health hazards due to dust inhalation.

4.4.7.4 Crushing.

LHD machines will dump broken rock into feeder breakers. Rock fragments as large as 2 by 3 by 5 feet will be crushed to less than 8-inch size. Areas around the feeder breakers will be provided with water fog sprays to reduce dust generation. In addition, feeder breakers will be located in the neutral split of the triple entry and any dust generated will be in the exhaust ventilation network.

4.4.7.5 Hauling

Broken rock from the feeder breakers will be dumped onto a 36-inch belt conveyor, providing the main haulage system for the mine. The conveyor belt will occupy the middle entry in the triple entry system used on the lower mining level. The conveyor belt will transport the muck to the shaft pocket where it will be stored until it is hoisted to the surface. On the upper mining level, feeder breakers will empty directly into the shaft pocket.

4.4.7.6 Hoisting

Muck is temporarily stored in the shaft pocket located just below each mining level. Each shaft pocket will have measuring pockets that automatically fill 13.5-ton ore skips. Production hoisting will be done using a balanced system dumping into a storage bin in the headframe on the surface.

The hoisting system will be designed for a maximum capacity of 7,500 tpd. For the proposed mining systems a hoisting rate of 2,100 tpd will be required to meet the development and mining schedules.

4.4.8 Mine Manpower Requirements

The majority of the work force underground will be hourly employees consisting of drillers, LHD operators, mechanics, powdermen, pipe fitters, electricians, conveyor beltmen and laborers, Table 4.6. The supervisory personnel will consist of a mine foreman, shift foreman, maintenance foreman, surveyors and engineers.

Hourly personnel will range from 70 to 102 per day for Phases III and IV, depending upon the amount of development completed. Supervisory personnel will not exceed six throughout the life of the project.

Personnel required for Phase V will be used primarily in surface restoration and site abandonment proceedures. If the facility remains open for a period of time, but not operated, a small crew of four men will perform inspection and maintenance work only.

4.4.9 Underground Equipment Requirements

A list of the underground equipment necessary to operate the proposed pilot mine is given in Table 4.7. Equipment selection has been based on

Table 4.6 Mine Manpower Requirements

Personnel	Phase III		Phase IV	
	Day	Afternoon	Day	Afternoon
Salary				
Mining Engineer	1	1	1	1
Shift Foreman	1	1	1	1
Mine Foreman	1	-	1	-
Maintenance Foreman	1	-	1	-
Surveyor	1	-	1	-
Surveyor Helper	1	-	1	-
Technician	1	1	1	1
Accountant	1	-	1	-
Secretary	1	-	1	-
	9	3	9	3
Hourly Underground				
LHD Operator	3	3	8	8
Driller	6	6	8	8
Rock Bolter	-	-	2	2
Powderman	2	2	6	6
Pipefitter	1	1	2	2
Mechanic	1	1	2	2
Mechanic Helper	1	1	2	2
Electrician	1	1	1	1
Electrician Helper	1	1	1	1
Welder	1	1	1	1
Backfillman	-	-	3	3
Conveyorman	2	2	1	1
Laborer	4	4	2	2
	23	23	39	39
Hourly Surface				
Mechanic	1	1	1	1
Mechanic Helper	1	1	1	1
Supplyman	1	1	1	1
Cage Tender	1	1	1	1
Hoistman	2	2	2	2
Janitor	1	-	1	-
Watchman	-	1	-	1
Heavy Equipment Operator	5	5	5	5
	12	12	12	12

Table 4.7 Underground Equipment List

Item	No. of Units	Description
LHD's	8	5-cy, 195 hp
ANFO Truck	3	2,000-16 cap.
Face Jumbo & Rock Bolter	3	2-boom percussion
Rock Bolt Machine	2	2-boom percussion
Lubrication & Fuel Truck	1	500 gal. cap.
Fan Drill	2	2-boom electric
Personnel Carrier	1	10-man capacity
Feeder Breakers	4	200 hp (150 kw)
Water Pumps	16	400 hp (300 kw)
Fans, Portable	6	30,000 cfm cap.
Conveyor Belt Drive	1	25 (19 kw)
Conveyor Belt	1,200 ft.	36-inch
Transformers	2	--
High Voltage Cable	7,500 ft.	--
Ventilation Tubing	7,500 ft.	30-inch diameter
Water Line	5,000 ft.	8-inch diameter
Backfill Pump	4	500 hp (370 kw)
Water Line	7,500 ft.	4-inch diameter
Portable Diamond Drill	1	30 hp (22 kw)
Fuel Line	2,300 ft.	3-inch diameter

best estimates of performance for currently available machines. Once detailed engineering for the proposed facility has been completed, modifications may be made in the final equipment selection. Drills, LHD's, rock bolters, ANFO trucks, lubrication and fuel trucks and personnel carriers will have diesel engines for tramming. All diesel equipment will be permissible with adequate ventilation provided based on brake-horsepower output.

A 10-man, diesel powered personnel carrier will be used to bring the miners to their various working areas. Three , 2-boom pneumatic face drills will be used for driving drifts and crosscuts. Each face drill will also be equipped with pneumatic roof bolters for rockbolting the back prior to drilling a new face. A second type of drill, a 2-boom electric fan drill, will be used to drill fan holes for chamber and pillar and sublevel stoping systems. Both drills can be equipped with enclosed cabs for noise and dust protection.

ANFO trucks will be used for transporting explosives to the face or fan round for pneumatically priming and loading drill holes.

Blasted muck will be removed from the face or stope by 5-yd^3 LHD machines. A total of eight LHD's will be required to complete the project as presently designed.

Four feeder breakers will be used to crush the rock to minus eight inches. The feeder breakers feed the crushed rock onto a 36-inch belt conveyor which will then convey the ore to the shaft pocket.

4.4.10 Underground Fuel and Power Requirements

Electric power will be brought into the mine down the 20-foot diameter shaft. Electric power will be required for fans, feeder breakers, water pumps, slurry pumps, conveyor belt drives, fan drills, underground maintenance shop, and a portable diamond drill. The combined power needs for the equipment is estimated at 173,000 kw per day, Table 4.8. A transformer on each level will be used to stepdown the power to required levels for each piece of equipment.

Diesel fuel for underground equipment will be brought into the mine by a pipe from the surface. The pipe will be used to fill the lubrication and fuel trucks on each mining level. An estimated 1,375 gallons of fuel per day will be required to operate the underground diesel equipment, Table 4.9.

Table 4.8 Underground Electric Power Requirements

Items	No. Units		Kw/Day
Fans - 30,000 cfm	10		7,200
Feeder Breakers	4		5,960
Water Pumps	16		121,728
Slurry Pumps	6		32,953
Conveyor Belt Drive	1		150
Underground Shop	1		1,490
Portable Diamond Drill	1		220
Fan Drill	2		3,140
		TOTAL	172,841

Table 4.9 Underground Fuel Requirements

Item	No. Units	Gal/Day
LHD	8	960
Face Drill & Rock Bolter	3	150
ANFO Truck	3	60
Lubrication & Fuel Truck	2	40
Personnel Carrier	1	4
Fan Drill	2	40
Rock Bolter	2	20
Miscellaneous	-	100

4.4.11 Communications

The communications system for the pilot mine will be a standard, hard-wired, page telephone network with extensions located at primary work areas, such as shaft stations, emergency facilities, and maintenance shop. This system will also be connected to the surface telephone network.

The pilot mine will also be used to test other underground communication systems currently being developed by the Bureau of Mines. Such systems will include high-frequency and low-frequency radio as well as combination radio and hard-wired systems. In addition, visual, audible, and olfactory mine alarm systems will be evaluated for use.

4.4.12 Health and Safety

The health and safety of underground and surface personnel will be of the utmost importance in this pilot mine design. Therefore, all persons while underground and on the surface will be equipped with hard hats, protective footwear, and safety glasses. All underground personnel will wear battery cap lamps and carry a self-rescuer.

All selected electrical equipment will be rated as permissible for gassy mines. Diesel equipment will also comply with regulations for gassy mines. Where conveyor belts are used they will be classed as fire resistant, and in addition, a steel water line will be placed parallel to the belt for fire protection.

The conveyor belt entry will also be isolated from the intake air entries by fire proof stoppings (constructed of cinder blocks). All equipment, either mobile or stationary, will include dry chemical fire extinguishers.

In case of emergency, telephones will be located near all working sections, feeder breakers, belt drives and other strategic locations. Located with the telephones will be first aid kits and stretcher sets. Personnel carriers will remain parked near the working sections at all times. Supervisors will carry portable methane and hydrogen detectors for monitoring possible gas build-up in the working areas.

In case of injury a first aid attendant and ambulance with life supporting equipment will be available on the surface.

Underground ventilation will be designed so that there is no reuse of fresh air. The main ventilation fan will be installed on the surface in a fireproof housing situated far enough away from the shaft opening so that the fan will not be damaged in case of underground explosion. The fan will be equipped with fireproof air ducts, explosion proof doors, and an automatic change over control with a diesel engine for auxiliary power.

Health and safety training will be given to all employees on the surface and underground. A special rescue team, composed of shift miners, will be trained for use in mine emergencies.

4.4.13 Research Studies

The secondary purposes of the pilot mine facility will be to provide needed data on the physical properties and hydrologic studies rock mass behavior of the deeper oil shales and test new mining concepts. The research will be divided into six main groups, rock mechanics, ventilation, blasting, stope backfilling, equipment design and evaluation, and novel mining concepts. Adequate time and space will be provided in the mining plan for detailed research and data collection programs.

4.4.13.1 Rock Mechanics Studies

Rock mechanics studies are divided into three general areas, rock substance physical properties, rock mass physical properties, and rock mass response. The data gathered from these areas will be adequate to provide realistic design parameters necessary for safe and economical mine designs. Personnel performing the rock mechanics studies will be provided by the Bureau of Mines on an as needed basis.

Rock Substance Physical Properties. Physical testing of rock specimens will be made to determine unit weight, porosity, compressive strength, tensile strength, shear strength, deformation modulus, Poisson's ratio, rock anisotropy, cohesion, and angle of internal frictional resistance. Testing methods will include unconfined compression, indirect and pure tension, biaxial and triaxial, direct shear, and sonic testing. The majority of these tests will be performed by the Bureau of Mines.

Rock Mass Physical Properties. Rock mass physical properties are a composite of the in situ stresses, size, quantity and orientation of discontinuities, and the rock substance physical properties. Orientation of the principal stress axes will be determined using three basic techniques, stress relief overcoring, photo-elastic stress monitoring, and hydro-fracturing. Discontinuities, such as joints, faults, and shear zone will be mapped and logged with respect to attitudes, spacing, continuity, infilling, planarity, tightness, water content, and structure type. Rock mass deformation modulus tests using borehole jacks and in situ shear testing will also be performed. The entire rock mass physical testing program will be carried out in the pilot mine facility.

Rock Mass Response. Monitoring of rock mass response to excavation and stress redistribution will be an important part of the rock mechanics studies. Various techniques, such as convergence monitoring, photo-elastic stress monitoring, and displacement monitoring will be used to collect the data. Subsidence monitoring on the surface will be done using a sophisticated survey net to evaluate displacement, displacement vectors and displacement vector velocity. These data will then be used to evaluate subsidence potential and rate. Rock mass response testing must necessarily be conducted at the pilot mine facility.

Continued

4.4.13.2 Ventilation Studies

Tests performed while drilling the exploratory drill holes indicate the presence of gases, such as methane and hydrogen sulfide. As a result, the pilot mine facility will be designed for gassy conditions under Title 30, Code of Federal Regulations. Ventilation studies will be performed to determine the safest and most efficient techniques for ventilating the large stopes. Remote sensing equipment will be evaluated for locating gas pockets that may develop in the open stopes.

4.4.13.3 Blasting Studies

The large production stopes envisioned for use in the oil shale deposits require large scale blasting to efficiently fragment large tonnages of rock. Studies will be made to determine the most effective powder factor and drilling patterns that will produce desirable fragmentation. Experimentation will also be performed to determine the most efficient explosive initiation sequence and gas and dust suppression system for the mining systems.

4.4.13.4 Stope Backfilling

Two mining methods to be tested in the pilot mine require spent shale backfilling as an integral part of the mining sequence. Experimentation with hydraulic, pneumatic, and mechanical transportation of fill material, together with emplacement techniques, will be made to determine the most feasible methods for backfilling stopes.

4.4.13.5 Equipment Design and Evaluation

Several types of equipment will be evaluated for use in large production, rapid excavation mining methods. Rotary hydraulic drills, LHD machines, conveyor belts, and other transporting techniques are among those that will be tested and evaluated. As problems are encountered, equipment modifications will be made or novel equipment will be designed to best alleviate the problems.

4.4.13.6 Other Mining Concepts

A portion of the pilot mine has been designated for testing other mining concepts not previously considered. Only those concepts with reasonable merit will be evaluated.

4.5 ABANDONMENT PLANS

The exact operating life of the proposed pilot mine is difficult to predict and it would be misleading to state the development and operating life is exactly nine years. Disposition of the mine and surface facilities at the end of Phase IV will depend on:

- The economic viability of the oil shale resources left in place.
- The continued use of the mine to research additional novel and potentially useful mining concepts in oil shale.
- The potential worth of the associated minerals.
- The extent of private industry interest in using the facility.
- The value of the proposed tract to adjacent lease holders.

The facility may also be put on a standby status, if conditions warrant, until a final decision is made as to its disposition. If the plant is leased, the lessee would assume all obligations to comply with current agreements and maintain all surface facilities and embankments. If modifications are proposed to put the mine into production, all current agreements, unless modified by the authorized government agency, will be enforced. Should the life of the proposed

facility be extended by the Bureau of Mines for continuing research and testing, all agreements and stipulations binding at that time will continue.

In the event the facility is decommissioned, the specific plans for abandonment are outlined below:

- Surface plant facilities - all salable items will be dismantled and removed from the site for salvage or sale.
- Concrete building foundations will be broken up and graded to approximate original ground contours.
- Hard surfaced roads will be broken up in-place and graded.
- Underground pipes and culverts will be broken up or left in place and plugged.
- Embankments will be leveled, filled with earth, or turned over to government or local wildlife organizations.
- Ore left in the stockpile will be covered with topsoil and revegetated. The stockpile will be covered in such a manner that in-place leaching is minimized.
- All knocked down areas and the plant site will be covered with topsoil and revegetated sufficiently to prevent wind and water erosion.
- Sidehill cuts and benches will be filled or smoothed.
- Mine shafts will be filled and plugged with rock.
- All secondary roads will be graded to remove drainage structures, and revegetated.
  , core holes & wells

Adequate maintenance time for vegetation will be provided to prevent invasion by undesirable species and to ensure the viability of new plants.

5.0 SOCIOCULTURAL ACTIONS

5.1 GEOGRAPHICAL RELATIONSHIPS AND TRANSPORTATION

Established living areas closest to the prototype mine site are Meeker, Rangely, and Rifle, Figure 3.6.

5.1.1 Highways

A secondary all-weather hard surfaced road, County Road 5, Figure 5.1, parallels Piceance Creek between Rio Blanco and Colorado Highway 64. Colorado 64 is a primary all-weather hard surfaced road. Both Rangely and Meeker are close to 64. Route 13 parallels Government Creek and is a primary hard surface road connecting Rio Blanco and Rifle, Figure 3.6. The traveling distance from the site to Rangely is approximately 50 miles; distance from the site to Meeker is 35 miles. Rifle is about 43 miles away from the site.

5.1.2 Air Service

Walker Field, on the outskirts of Grand Junction, is the largest airport facility between Denver and Salt Lake City. It is a complete service airport, equipped for instrument landing, and is the only airport in the region providing regular scheduled airline service. Frontier Airlines, United Air Lines, and Western Air Stages provide direct service to many cities and towns. Terminal facilities include airline ticket counters, waiting area, restaurant, and car rental agencies. Commercial service and repair facilities are provided as well as light aircraft sales and pilot instruction. The FAA and U.S. Weather Bureau are both located at Walker Field.

Small municipal airports are located at Meeker, Rangely, Rifle, and Glenwood Springs. They all have asphalt landing strips. Services vary from airport to airport, but include charter service, flight instruction, fuel service, aircraft maintenance, and air taxi/freight services. There is also a private unpaved landing strip, with no services, owned by General Petroleum in the vicinity of Piceance Creek in Rio Blanco County.

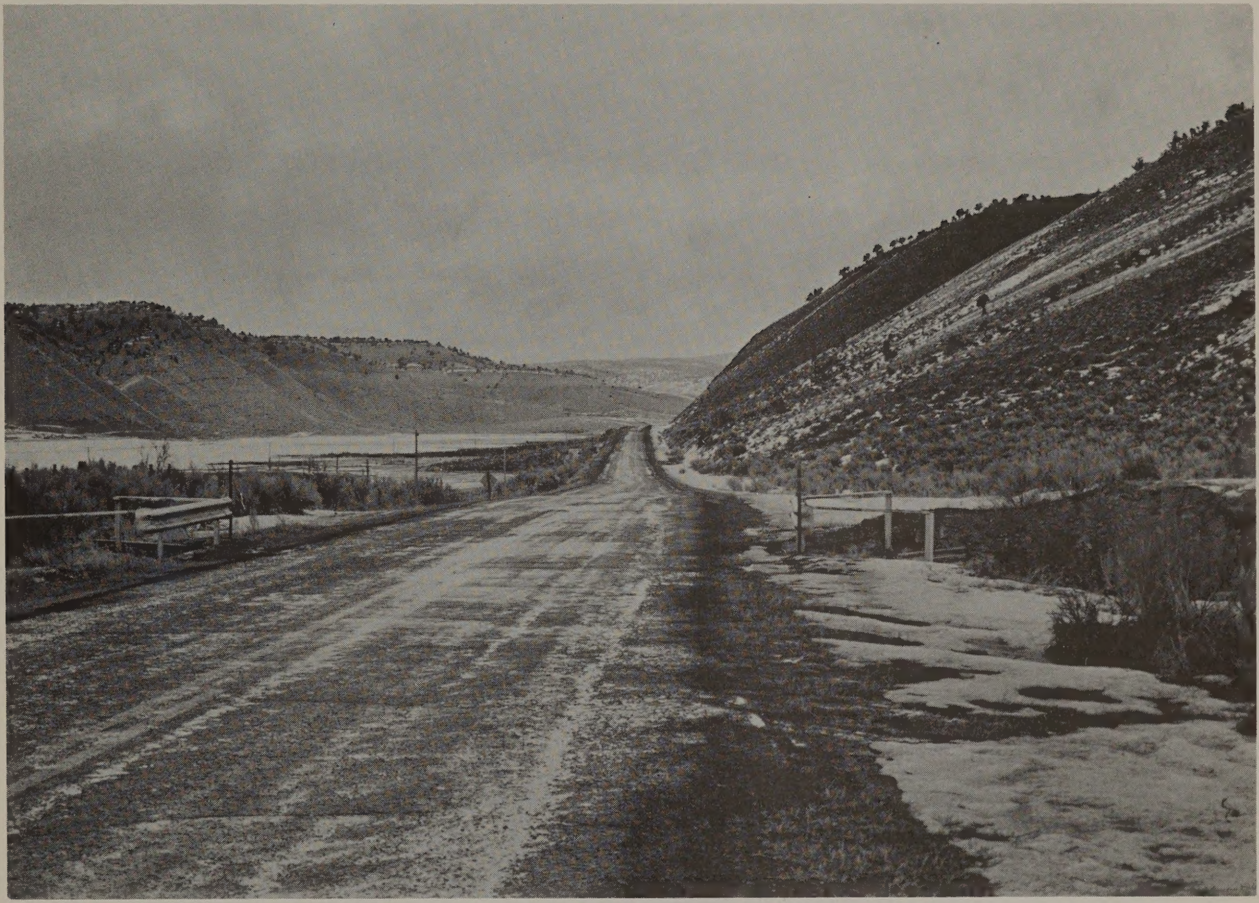


Figure 5.1 County Road 5, Piceance Creek Road

5.1.3 Railroads

The main Denver and Rio Grande Western Railroad line runs through the region roughly along the Colorado River, serving Glenwood Springs, Rifle, Grand Junction, and towns between these cities. In addition to continual freight service every day, the line provides east and westbound passenger service every other day.

5.1.4 Bus Service

There are two bus companies operating in the region. Essentially, each company covers different routes. Continental Trailways serves the region with three buses daily, both eastbound and westbound, along Routes 6 and 24 between Denver and Salt Lake City. In addition, Grand Junction is served by two buses daily to and from Pueblo and one bus daily to and from Durango. The Wilderness Transit Company operates one bus a day, in each direction, between Craig and Grand Junction through Meeker and Rifle.

5.2 HISTORY

5.2.1 Rangely

Rangely was founded on the summer grazing ranges of Rio Blanco cattlemen when the oil field was discovered in the mid-1940's. This oil field was one of the world's richest during its most productive years, and Rangely's population increased from about 20 to more than 4,000 during its boom years.

The town's social and economic ties have historically been focused more strongly toward Utah than Colorado. In July 1946, the Denver Post called Rangely "an economic suburb of Salt Lake City". The isolation of Rangely from the rest of Colorado is partly because Utah is more accessible physically, but for nearly 40 years citizens in Rangely asked the State of Colorado for a road through Douglas Pass to Grand Junction. The road was finally built in 1960, but only after a three-county coalition was formed.

Rangely residents have survived the boom of the 1940's and are accustomed to industry-related workers living in the town. Rangely is positive about expansion and new growth. The town has the social, historical, and geographical capacity to expand without using agricultural land for growth, Figures 5.2, 5.3.

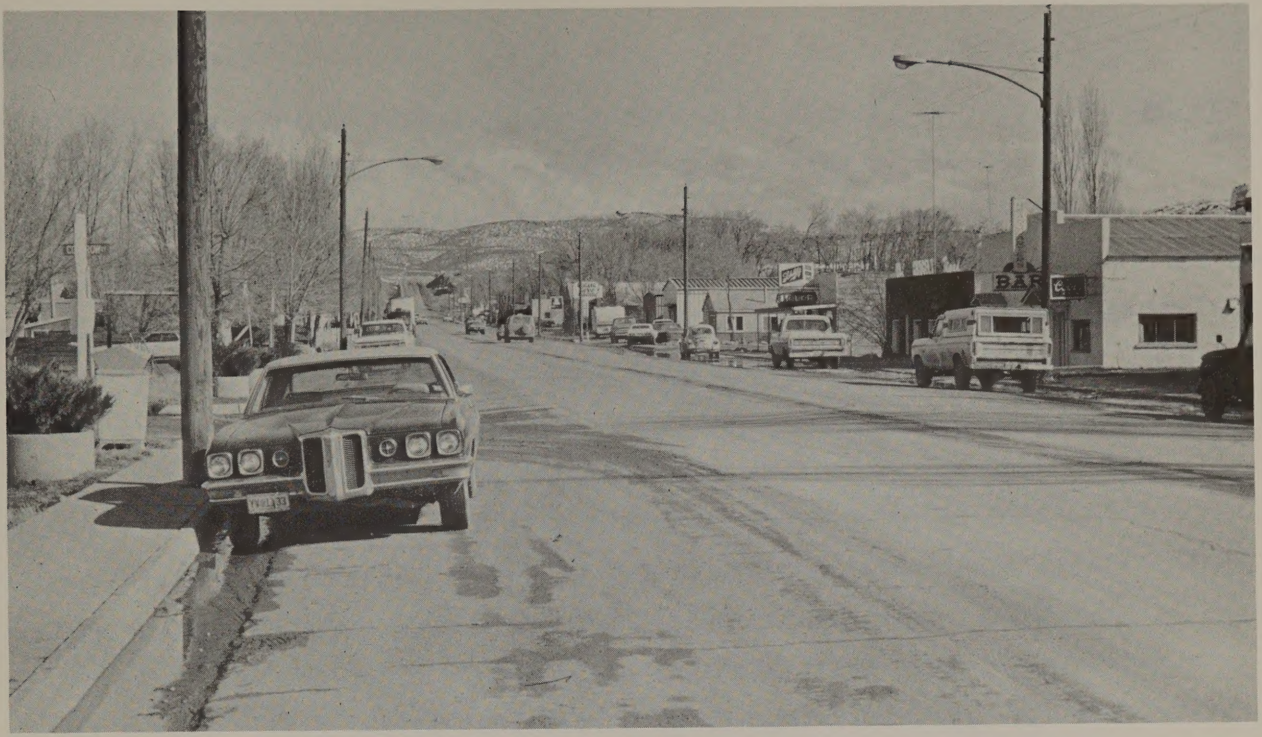


Figure 5.2 Highway 64 Through Rangely

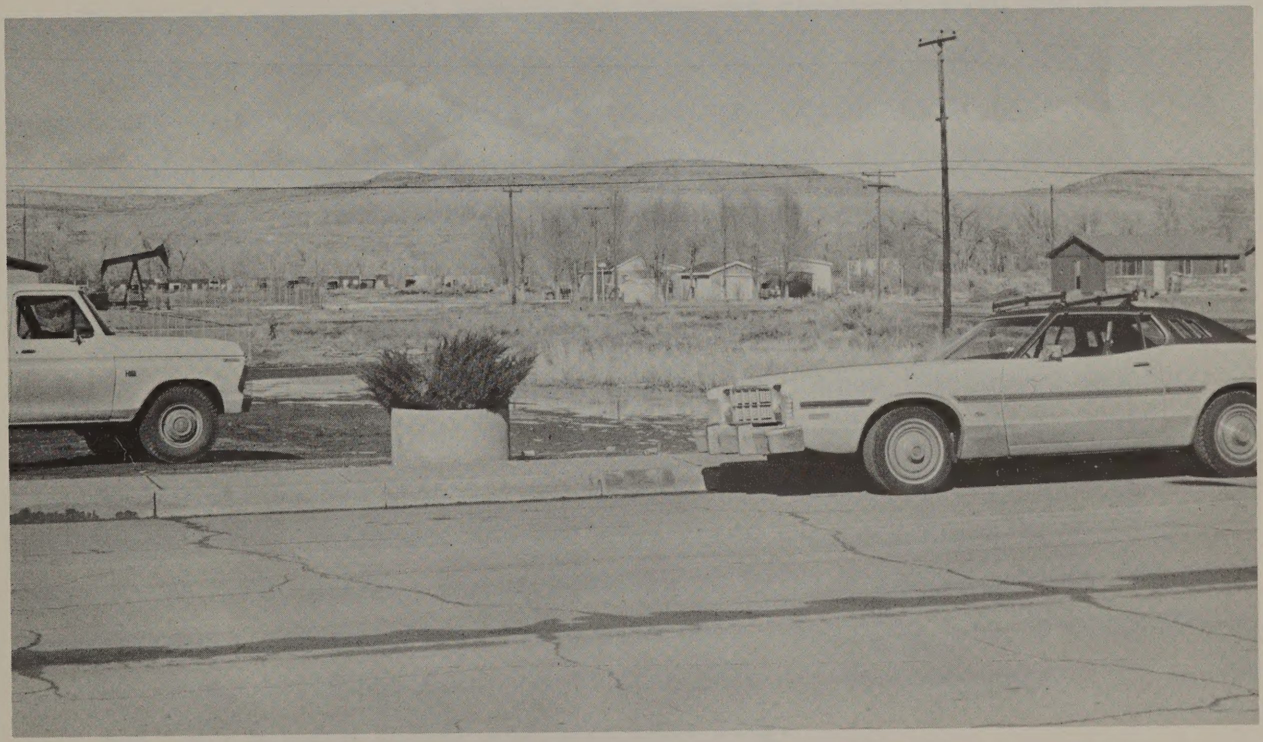


Figure 5.3 Part of Rangely Field, an Oil Well Next to Residential Area

5.2.2 Meeker

After the slaying of Indian Agent Nathan C. Meeker, in 1879 a permanent military camp was established in Meeker, on the site of the courthouse building. In 1883 the military installation was closed and all the buildings were sold. The new residents of the ready-made town decided unanimously on the name of Meeker, after the slain Indian Agent. Meeker was incorporated in 1885 and for the next 20 years was the only incorporated town in northwest Colorado. It became the center for agriculture, ranching, and banking in the area.

Pioneers from all over the United States settled in Meeker and many families in the town today are descendents of those original settlers. A strong sense of community history is shared by the residents of Meeker. They support the White River Museum and the Historical Society. The friendly, open nature of Meeker residents is reflected in their "take care of one another" social system. This system contributes to community strength but also leaves the community highly vulnerable to negative impacts.

Residents are not anti-growth but they are concerned with the preservation of their system, which is based on common knowledge and trust. Because they have heard energy-related growth rumors before, residents of Meeker are taking a wait-and-see-position, and therefore are not included in any decision making activities which will influence them, Figures 5.4, 5.5.

5.2.3 Rifle

Rifle's history is initimately linked with the railroads' movement across Colorado. Shortly after the turn of the century, when the Denver and Rio Grande tracks were built into Rifle, the townsite was moved to a location more convenient to the tracks. Rifle was the most conveniently located settlement with a railhead, and for many years the only place from which ranchers shipped cattle. So, in addition to being a stopping place for east-west shipments and travelers, Rifle also drew trade from a north-south direction. Today Rifle has Colorado 13, the only all-weather highway connecting I-70 and I-80 between Denver and Salt Lake City.

Since the Anvil Points test programs began in 1929, Rifle has called itself "Oil Shale Capital of the World." Other industries have also centered in Rifle; Union Carbide Corporation and Occidental both employ workers from Rifle.

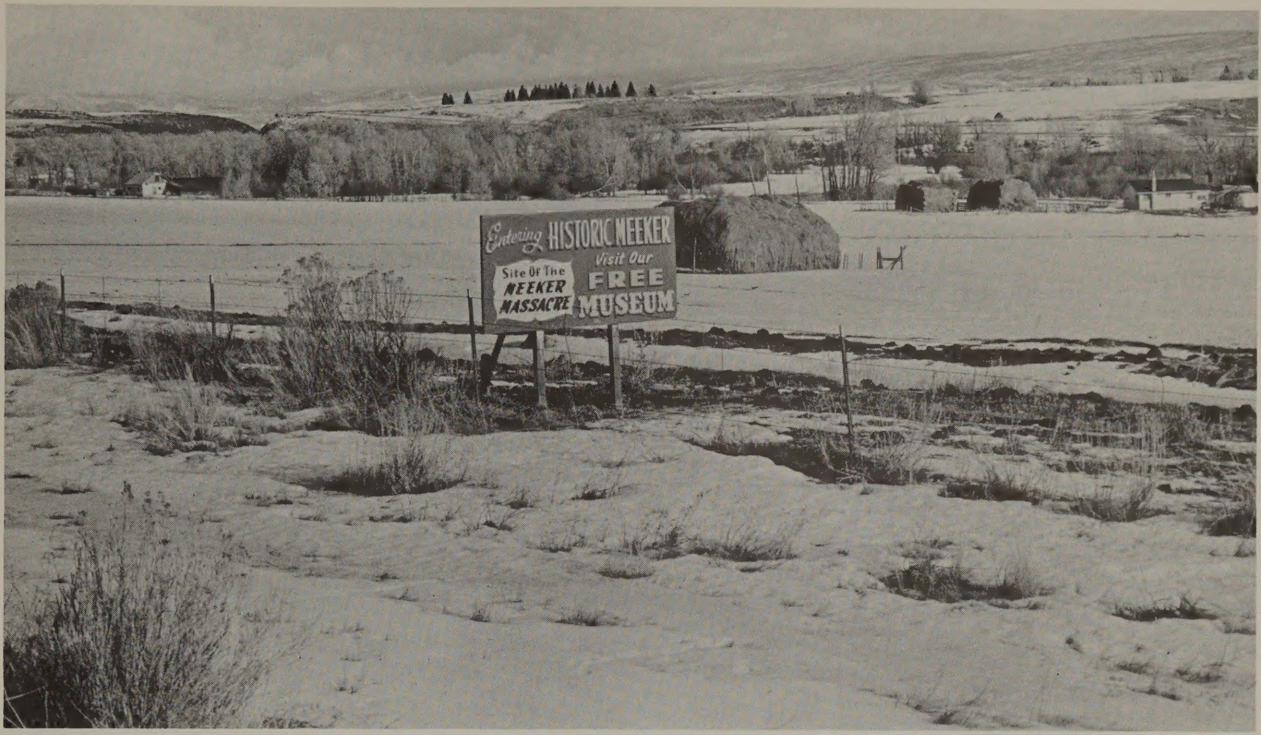


Figure 5.4 Meeker Residents are Proud of Their Historic Background

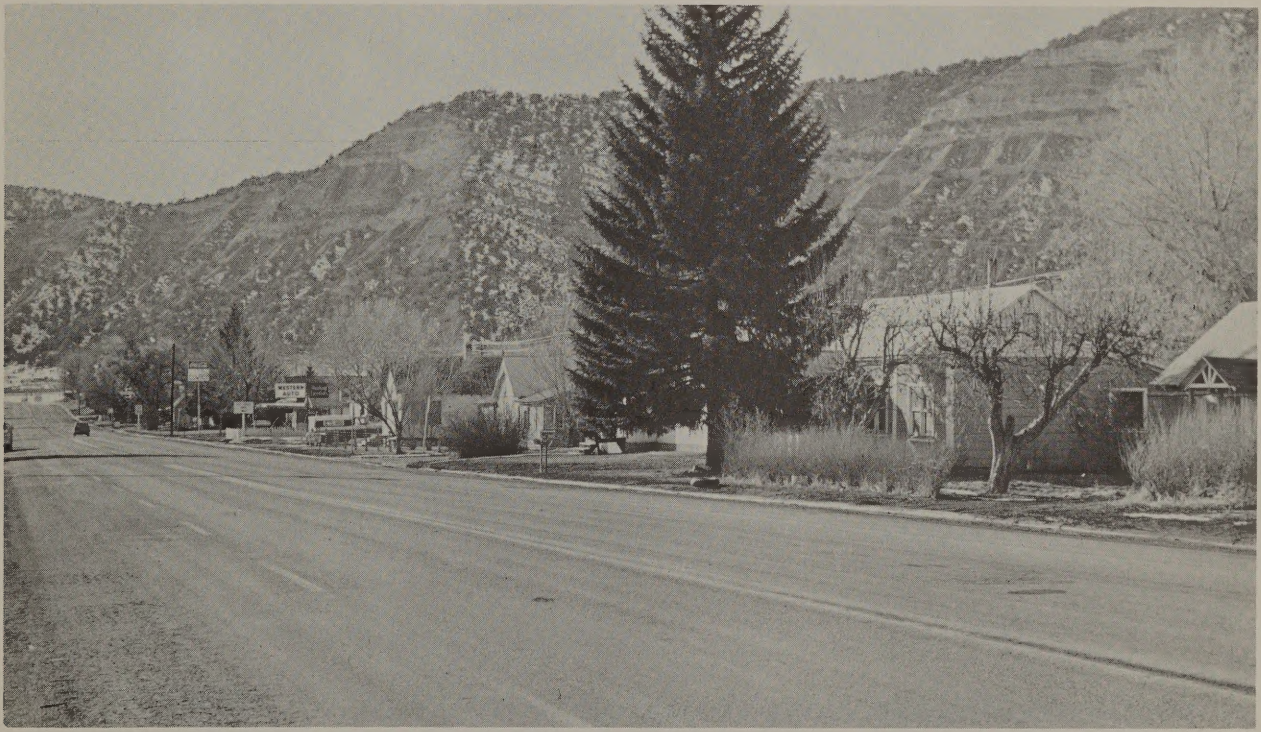


Figure 5.5 Highway 13 Through Meeker

Many Rifle citizens are, or have been, employed by industries in the area. Since 1929, the town residents have been expecting oil shale development. Rifle's viability as a small town between Glenwood Springs and Grand Junction could be improved by oil shale developments. Many Rifle residents look forward to the oil shale industry centering near their town, Figures 5.5, 5.6

5.3 PUBLIC FACILITIES

5.3.1 Housing

Housing characteristics in Rifle, Meeker and Rangely are summarized on Table 5.1. At the present time, it is estimated that housing is available in Rangely, to a smaller extent in Rifle, but perhaps not at all in Meeker. However, construction of space for 400 mobile homes in Meeker, 290 in Rifle, and 700 in the Grand Valley area have been made (11).

5.3.2 Water

Rifle's water system has some excess capacity and the town is searching for funds to upgrade the water system. Rangely's water system has some excess capacity, but Meeker's system is at capacity. Both towns are in the process of enlarging their water systems (11, 12, 13).

5.3.3 Sewage

Rifle's sewage system was operating at 66 percent capacity in 1973. Presently, Rangely's sewage system is about 75 percent utilized, but Meeker's sewage system is operating at full capacity. Both Rangely and Meeker are devoloping plans to enlarge their systems (11, 12, 13).

5.3.4 Utilities

Rifle receives electricity and natural gas from the Public Service Company of Colorado, an investor-owned utility. The town's electric line is 69 kv. Telephone service to Rifle is from Mountain Bell.

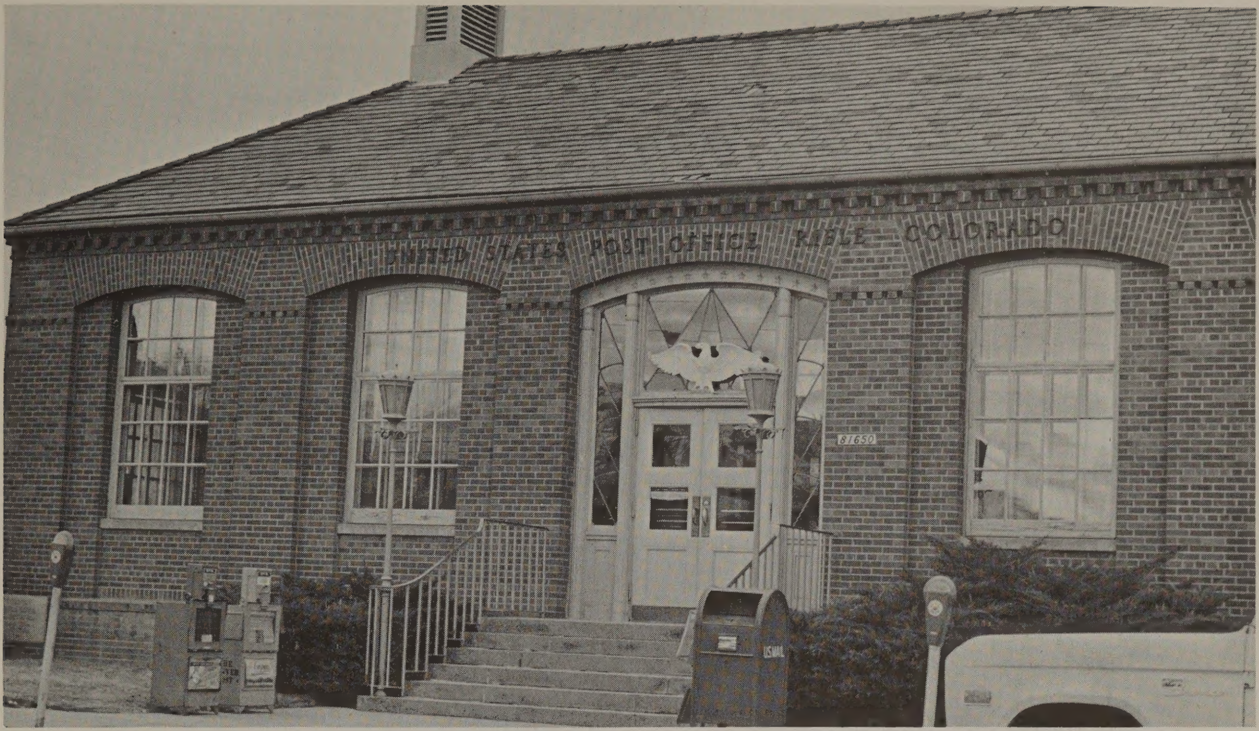


Figure 5.6 U.S. Post Office in Rifle

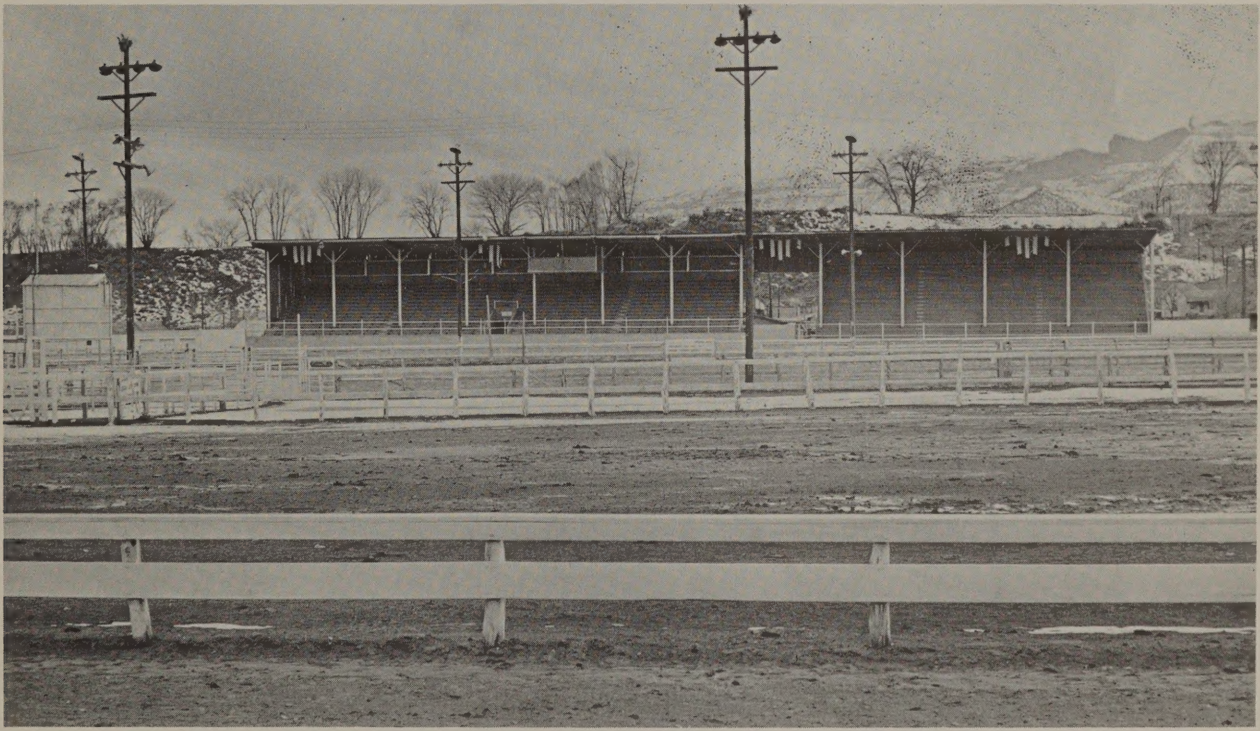


Figure 5.7 Fairgrounds at Rifle

Table 5.1 Selected Housing Characteristics, 1970

	Number of Housing Units	Owner Occupied Units	Renter Occupied Units
Rifle	803	503	236
	Median Value/Rent	$12,400	$69
Meeker	660	393	150
	Median Value/Rent	$11,300	$65
Rangely	502	273	165
	Median Value/Rent	$11,800	$79

Source: Wengert, 1973

Meeker receives electricity from the White River Electric Association, which is a cooperative and a member of the Colorado-Ute Association. The town receives natural gas services from Greeley Gas. Telephone service is provided by Mountain Bell.

Rangely's electrical service is provided by Moon Lake Electrical Association, which is a cooperative and a member of the Colorado-Ute Association. They receive natural gas from Western Slope Gas Company and Cascade Natural Gas Corporation. Mountain Bell also provides Rangely's telephone service (13).

5.3.5 Health

All three towns have hospitals and Grand Junction has three. Meeker and Rifle also have nursing homes. None of these communities, however, have good health planning (12, 14).

5.3.6 Educational

Both Meeker and Rangely have excellent student/teacher ratios. Rio Blanco County's average educational attainment is 12.4 years, and Garfield County's is 12.2 years (15).

5.3.7 Other Facilities

Rifle and Meeker are largely self-sufficient in terms of shopping facilities. Rifle's shopping facilities are the best of the two towns, but Grand Junction is very convenient to Rifle shoppers. Residents of Rangely have traditionally traded in Vernal, Utah, and as a result their shopping facilities are not well developed.

Recreational facilities in the three towns are not highly developed. Much recreational activity concentrates on informal outdoor activities. Downhill ski areas are within driving distance of the Piceance basin.

5.4 PROJECT PHASING

The mine project has been divided into five phases. Phase I, site preparation, will require a work force of 36. This phase will last 12 months.

Phase II, shaft sinking and surface plant construction should last about 2.5 years. Three shifts per day will be worked during this phase, and approximately 20 workers will be required per shift.

Phase III has a duration of nine months during which mine development and the ventilation circuit will be completed. Two shifts per day will be worked and 44 workers will be required for each shift. These workers will remain with the project for about five years.

Phase IV is the mine testing phase. During this phase an additional 16 people per shift will be hired, and remain on the job for about four years.

Phase V is the final phase of operations presently planned for the mine. The work force requirements for this phase vary from 20 workers per shift to a skeleton crew of four whose primary task is mine inspection. These workforce figures are summarized on Figure 4.2.

5.5 RECOMMENDATIONS

Community acceptance of a proposed project benefits the community as well as the industry. To establish acceptance of an industry, communication between the industry and the community is essential. Communities in the Piceance basin area should be informed of pending developments nearby and invited to take part in decision making that will affect them.

The greatest number of workers employed at a single time on the proposed project is about 120. This small number and their families could probably find housing near the plant wihout too much difficulty. However, the availability of housing and public facilities will probably present problems to incoming workers if other oil shale developments are operating in the Piceance basin. Whenever possible, workers who already live near the Piceance basin should be hired. Efforts should be made to train workers for jobs, so that employee longevity is high. Many people around the basin have held industrial jobs in the past and could readily adapt to the proposed operation.

Hiring workers through family or friend contacts increases the acceptance of an industry in a community. Often, workers are inclined to produce more and remain with their jobs longer when hired in this manner.

Because the travel distances to the mine site are large, consideration

should be given to bus transportation for workers. Bus transportation will minimize various impacts on the Piceance basin, reduce the required parking space at the site, and save the workers time and money.

5.6 EFFECT OF ABANDONMENT AND STANDBY

The effects of either abandonment or standby actions will depend to a certain extent on what other industries will be in the area, and whether other jobs will be available. If jobs were available elsewhere, and laid-off employees wanted work, the effect could be the added expense of training new employees when operations began again. If work were not available elsewhere, or if workers did not want jobs, an undesirable increase in unemployment compensation spending could result. To avoid placing this burden on the citizens of Colorado, efforts should be made to place employees in new jobs if abandonment or standby actions become necessary.

6.0 SUMMARY OF MITIGATING ACTIONS

This section summarizes mitigating actions that have been presented throughout the development plan.

6.1 AIR QUALITY

6.1.1 Underground

Three major air contaminants will be produced during mine development and mining operations. They are dust, diesel exhaust fumes, and blast fumes.

Water sprays and water fogging devices will generally be used to control dust generated in the following areas:

- Muck piles.
- Feeder breaker (crushers) loading and discharge points.
- Conveyor belt discharge into the ore bin.
- Measuring pocket loading points.
- Haulageways (underground roadways).

All underground drilling will use water flushing for chip removal to control dust generation.

Sufficient ventilation will be supplied to dilute diesel exhaust fumes to safe, comfortable levels. Wet scrubbers will also be used to cool exhaust gases, remove some of the particulate matter, and reduce the amount of CO generated. The amount of ventilation required for diesel exhaust dilution will also provide more than adequate dilution for gases generated by blasting.

6.1.2 Surface

Gas and particulate contaminants exhausted from the mine will be sufficiently diluted to cause negligible impact at the surface.

Major areas of dust generation on the surface will be:

- Access roads.
- Ore storage bin during dumping.
- Truck loading point.
- Truck haul roads.

Access and haul roads will be watered regularly as needed. Loading and dumping points will be provided with water sprays. However, ore hoisted to the surface will probably have been wetted previously and dust generation, if any, will be minimal.

6.2 WATER QUALITY

Water from the underground mine, runoff from the oil shale stockpile, and runoff from the mine plant area will be pumped to the saline water storage dam and diluted to acceptable quality before discharge into Horse Draw. Water discharge rates will be controlled to prevent excessive erosion. Monitoring stations will be maintained near the confluence of Horse Draw and Piceance Creek to ensure water quality standards are met.

Suspended sediment in the water will be lessened by runoff control on roads, grading and ditching of the surface plant site, and limiting the surface disturbance due to drilling pad construction. Seismic lines will utilize existing roads and trails as much as possible; new roads and trails will not be bladed.

Where surface stripping of soil is required, the soil will be stockpiled. Revegetation will commence as soon as possible to reduce erosion and sediment loads during periods of runoff.

Sewage pollution will be prevented through the use of composting toilets underground, in the office/changehouse, and in the repair shop. Biodegradable soap will be furnished in the shower areas.

Fuel storage tanks will be surrounded by impermeable, protective berms with sufficient capacity to prevent fuel spills on the surface. Waste oil from machinery will be stored and returned to the supplier for recycling.

6.3 NOISE CONTROL

Surface structures containing noise generating machinery will be soundproofed as much as practicable, to reduce outside noise levels. All surface and underground mobile equipment will have properly maintained standard muffling systems. Where muffling systems are inadequate, personnel will be required to wear approved ear protective devices.

6.4 AESTHETIC CONSIDERATIONS

Above ground structures will be painted colors that blend with the landscape. Disturbed surface areas will be revegetated as soon as possible. Roads and building sites will be provided with well maintained drainage systems to prevent gullying or sheet erosion.

The main access road and power line will utilize the same corridor. Two-way radio-telephone communications will be used to eliminate the need for telephone poles.

6.5 FIRE PROTECTION, HEALTH AND SAFETY

All underground and surface equipment will carry dry chemical fire extinguishers. A 20,000 gallon capacity potable water tank will be used for emergency fire fighting. In addition, the 5,000 gallon capacity water truck will also provide mobile fire fighting support. Surface fuel storage tanks will be constructed according to National Fire Protection Association standards. Only permissible equipment will be used underground. Conveyor belts will be classed fire resistant with a steel water-line providing additional fire protection.

Hard hats, protective footwear, and safety glasses will be required for all surface and underground employees. Underground personnel will have individual battery cap lamps and self rescuers. Telephones, first aid kits, and stretcher sets will be located near working sections, feeder breakers (crushers), conveyor belt drives, and other strategic locations. Personnel carriers will remain parked near working sections at all times. Supervisors will carry portable gas detectors. An individual trained in first aid and an ambulance will be available on the surface in case of injury.

Underground ventilation will be designed so that there is no reuse of fresh air. The primary ventilation fan will be located on the surface in a fire and explosion proof building. The fan will be equipped with fireproof air ducts, explosion doors, and an emergency back up power source. In case of emergency, the ventilation shaft will also be used as an emergency escapeway.

Health and safety training will be given to all employees. A special rescue team, composed of supervisory personnel and shift miners, will be trained for use in mine emergencies.

6.6 SOCIOCULTURAL

Sociocultural impacts of the proposed pilot demonstration mine will be mitigated by the following activities:

- Workers will be hired from surrounding communities whenever possible.
- Job and first aid training will be provided to skilled and unskilled laborers.
- Industry/community communication will precede mine development activities.
- Upon project completion, employees will be given aid in finding new jobs.
- The job skill base of surrounding towns will be broadened by the influx of skilled mine personnel.

6.7 ROADS

The main access will be constructed high on the flood plain to minimize impact to the drainage system. Adequate drainage ditches and permanent culverts will be maintained to prevent erosion as shown in Figure 6.1. Other access and haul roads will be graded to control rut and gully development. All roads will be wetted to control dust. Road construction will be done according to AASHO standards. Attempts to reduce road traffic by encouraging car pools will be made.

6.8 REVEGETATION

Dam sites and the surface plant site will be cleared, grubbed,and stripped prior to construction. Topsoil will be stockpiled and used later for revegetation. After construction is complete, areas on the surface plant site not used for access or storage will be revegetated. In addition, the downstream faces of dams will be revegetated.

Rock remaining in the ore stockpile will be revegetated upon completion of the project.

6.9 SUBSIDENCE

The maximum vertical subsidence of the surface due to mining operations as presently planned is expected to be no greater than 1.3 feet. Surface damage due to horizontal compressive and tensile strains will be negligible. A sophisticated surface monitoring network will be maintained to monitor subsidence effects. All subsidence effects will be contained in an area of less than 100 acres.

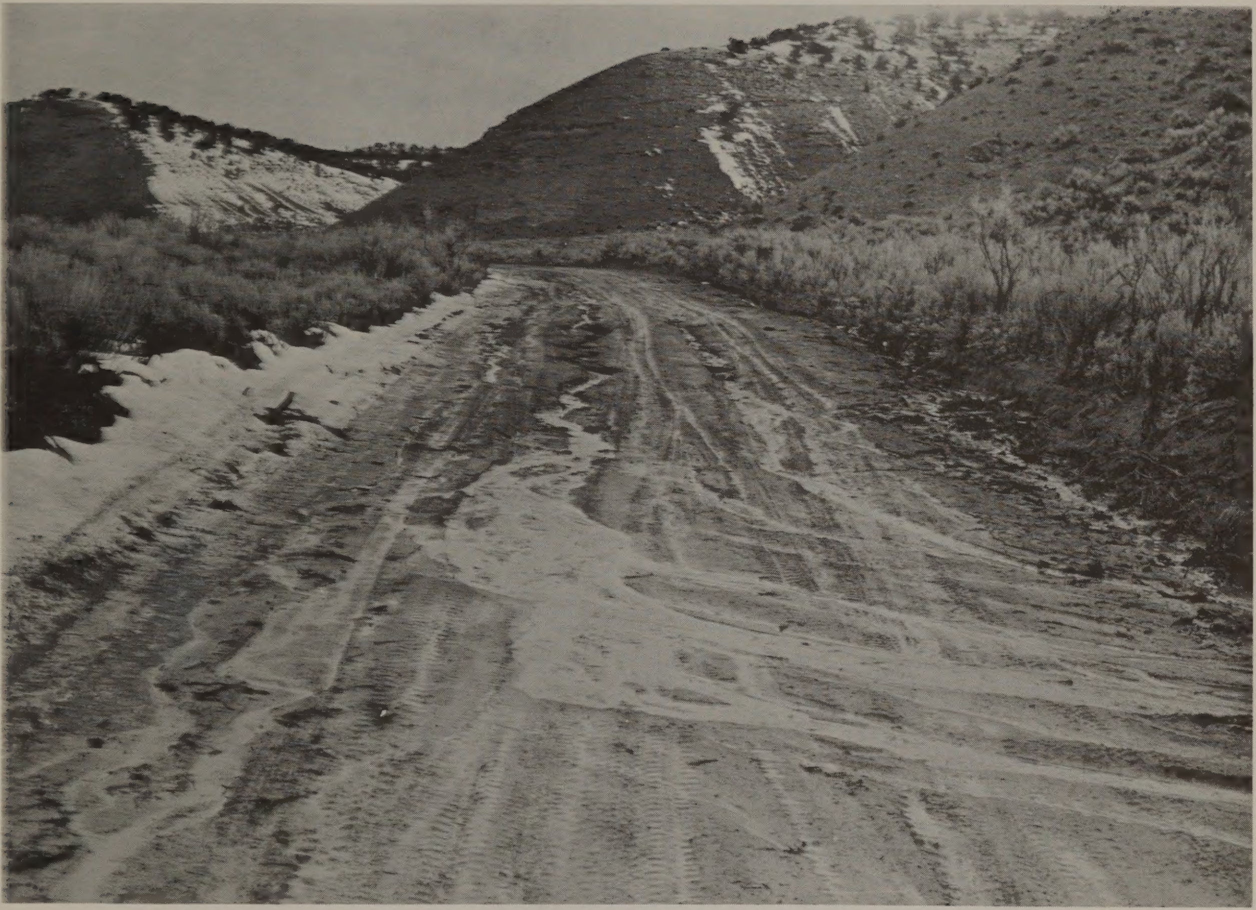


Figure 6.1 Erosion of Unimproved Dirt Road to Proposed Site

6.10 WILDLIFE PROTECTION

Hazardous areas such as explosive and cap magazines, power substation, exhaust fan and shaft, production/service/intake shaft, will be fenced by a heavy duty chain link fence to prevent wildlife and livestock from entering. These individual compounds are not large enough to cause wildlife migration and movement patterns to change considerably.

Raptor proof, H-Frame, two-pole power poles will be used to bring the power line on site. Raptor perches and minimum power line horizontal spacing of 20 feet will be standard.

7.0 ABANDONMENT AND RECLAMATION PLANS

When all research activities are completed in the proposed pilot demonstration mine, the facility may be leased by the Department of Interior or abandoned. If the facility is not leased, decommissioning and reclamation activities will begin and take approximately eight months to complete. The following subsections describe the abandonment and reclamation plans during the final phase of operation.

7.1 MINED SHALE STOCKPILE

Since the mined oil shale will have a potential market value, attempts will be made to sell the ore and have it removed from the site. For this reason, the stockpile will be considered temporary and not revegetated as it is constructed.

During the abandonment phase, however, any ore remaining in the stockpile will be revegetated. A recommended method for revegetation is presented below (16):

- The stockpile will be contoured to blend with the surrounding area.
- Three feet of coarse rock will be placed over the oil shale to form a capillary break.
- A layer of finer material will be placed over the coarse rock to help retain soil moisture.
- Stockpiled topsoil will then be spread over the layer of fine rock up to a thickness of about two feet and revegetated.

This system of revegetation will inhibit the upward migration of soluble salts thereby reducing plant root damage. In addition, the finer layer of rock will help retain moisture in the soil and prevent the downward leaching of oil shale.

7.2 DAMS

The water catchment dam and saline water storage dam will be disposed of in one of four possible ways:

- Impoundment areas will be filled and revegetated.
- Earthfill embankments will be knocked down, graded and revegetated.
- Dams will be turned over to Federal, state or local wildlife organizations.
- Dams will be left as permanent drainage control structures, in accordance with appropriate government approvals and permits.

If the dams are used as wildlife watering areas, full responsiblity for site and embankment maintenance will be transferred to the receiving party. Material from knocked down embankments will be used as fill for other reclaimed areas. Spillways will also be replaced with rock and fill material.

7.3 ROADS

Existing hard surfaced roads (built only if necessary as a mitigating action) will be broken up in place, graded and revegetated. Secondary roads will be graded, drainage structures removed, and revegetated. Sidehill cuts and benches will be filled or smoothed and revegetated. All signs will be removed.

7.4 BUILDINGS

Prefabricated buildings will be dismantled and removed. Other buildings will be knocked down and all metal and lumber salvaged. Concrete foundations will be broken up in place and graded to approximate original contours. All knocked down areas will then be covered with topsoil and revegetated. All fences will be salvaged.

7.5 POWER CORRIDORS

The electric substation will be dismantled and removed by the White River Electric Company. Foundations will be broken up in place, graded, and revegetated. Power lines and poles will be salvaged by the electric utility.

7.6 SHAFTS

Headframe and hoisthouse will be dismantled and removed. Concrete foundations and footings will be broken in place, covered with topsoil and revegetated. Shaft dividers and guides will be removed from the shaft, the shaft collar broken up to below grade, and the shaft filled with broken rock. The entire area will be graded and revegetated.

7.7 SUBSIDENCE DAMAGE RECLAMATION

Surface subsidence effects induced by underground mining will be minimal. The maximum expected vertical subsidence, using the proposed mine design in Section 4.0, is 1.3 feet. The largest horizontal ground strains may not produce noticeable surface damage. However, if the proposed mining systems are modified and result in greater subsidence, steps for reclaiming the disturbed area

will depend on the amount of damage and whether it will be safe for machinery to operate over the area.

7.8 REVEGETATION

More studies on vegetation of processed shale have been undertaken than studies on revegetation of artificial soil profiles in climates similar to the Piceance Creek basin's. Oil shale contains large amounts of soluble salts that inhibit plant growth. Continuous leaching of oil shale is therefore required to revegetate raw shale covered only by a thin soil layer.

Two types of land disturbances will require revegetation. All disturbances resulting from exploratory core hole drilling, road and power corridor construction, and construction of underground and surface facilities will be revegetated. Any stockpiled oil shale remaining at the time of decommissioning will also require revegetation.

7.8.1 Revegetation of Disturbed Surfaces

Disturbed surfaces on the site will be relatively limited in extent. However, to further limit erosion damage, disturbed land will be revegetated as soon as possible. In most locations, soil will be stripped and stockpiled before disturbances begin. The topsoil will be replaced before revegetation except small disturbed areas where soil stockpiling is not practical. Then subsoil may be revegetated directly.

Slope roughening practices will be used to decrease runoff and slow water movement. Water's ability to detach and transport soil particles is reduced by these practices. Scarification and pocket cuts at varying intervals on a slope are two roughening practices usable on the site.

Revegetation in the Piceance basin will be controlled by seasonal climate. Surface disturbances that occur in the very late fall or winter cannot be successfully revegetated promptly. Land disturbed at this time of year will be protected by cover material. Many different types of cover materials are on the market; when cover material is applied as an initial step in revegetation, it should also be a good mulch.

Topsoil will be replaced and seeded. Experiments are currently in progress to determine the best types of vegetation, combinations of vegetation, timing of seeding, method of seeding, rate of seeding, and types of fertilizer for use in the Piceance basin.

Mulches hasten the establishment of vegetation by increasing water infiltration, moisture retention, and lowering soil temperature and evaporation. Many mulches have been tested, and their suitability and disadvantages vary under different conditions. Straw is widely used as a mulch because of its demonstrated success, availability, and low cost. It is best to use straw in combination with some kind of stabilizing netting to keep it intact and in place.

Preliminary soil surveys indicate that fertilizer will be necessary only in minimum amounts. Further analyses will determine specifically the nutrient and organic content of the soils, and the type of fertilizer necessary.

Revegetation in the semi-arid west is limited by low soil moisture. Annual precipitation at the proposed site area ranges from 12 to 25 inches per year, approximately half of which occurs as snow. Although some species in the basin can be successfully reseeded without supplemental irrigation, revegetation plans should not depend on average rates of rainfall for initial plant establishment. A sprinkling system will be used to aid in establishment of revegetation. It is expected that the three wells in the upper aquifer will provide plenty of water for irrigation.

Seeded areas will be maintained following initial revegetation procedures. Additional fertilizer and irrigation may be necessary in the second year of establishment. Undesirable plants can probably be controlled by prompt revegetation and mechanical methods such as tilling.

7.8.2 Vegetation of Mined Shale Stockpile

Initially, the shale stockpile will be graded to approximate surrounding ground contours. Once the contouring is completed, creation of an artificial soil profile, discussed in 7.1, will begin. After the soil profile is in place, the vegetation procedures described in 7.8.1 will be followed.

7.9 POTABLE WATER WELLS

Two of the three potable water wells will be dismantled and capped during the abandonment phase. The third well will be used as a source of irrigation water for revegetation purposes. At the end of the second year, assuming revegetation is completed, the well will be dismantled and capped.

Mulches hasten the establishment of vegetation by increasing water infiltration, moisture retention, and lowering soil temperature and evaporation. Many mulches have been tested, and their suitability and disadvantages vary under different conditions. Straw is widely used as a mulch because of its demonstrated success, availability and low cost. It is best to use straw in combination with some kind of stabilizing netting to keep it intact and in place.

Preliminary soil surveys indicate that fertilizer will be necessary only in shallow amounts. Further analyses will determine specifically the nutrient and organic content of the soils, and the type of fertilizer necessary.

Revegetation in the semi-arid west is limited by the soil moisture. Annual precipitation at the proposed site area ranges from 12 to 15 inches per year, approximately half of which occurs as snow. Although some species in the basin can be successfully reseeded without supplemental irrigation, revegetation plans should not depend on average rates of rainfall for initial plant establishment. A sprinkling system will be used to aid in establishment of revegetation. It is expected that the three wells in the upper aquifer will provide plenty of water for irrigation.

Seeded areas will be maintained following initial revegetation procedures. Additional fertilizer and irrigation may be necessary in the second year of establishment. Undesirable plants that are growing will be controlled by prompt revegetation and mechanical methods such as tilling.

7.2.2 Vegetation of Mined Shale Stockpile

Initially, the shale stockpile will be graded to approximate surrounding ground contours. Once the contouring is completed, creation of an artificial soil profile, discussed in 7.1, will begin. After the soil profile is in place, the vegetation procedures described in 7.2.1 will be followed.

7.3 Potable Water Wells

Two of the three potable water wells will be dismantled and capped during the development phase. The third well will be used as a source of irrigation water for revegetation purposes. At the end of the second year, assuming revegetation is completed, the well will be dismantled and capped.

REFERENCES

1. Cashion, W.B., and J.R. Donnell, 1972, Chart Showing Correlation of Selected Key Units in the Organic-rich Sequence of Green River Formation, Piceance Creek Basin, Colorado, and Uinta Basin, Utah: U.S. Geological Survey Oil and Gas Investigations Chart OC-65.

2. Murray, D.K., and J.D. Haun, 1974, Introduction to the Geology of the Piceance Creek Basin and Vicinity, Northwestern Colorado; RMAG Guidebook to the Energy Resources of the Piceance Creek Basin, Colorado, 25th Field Conference.

3. Dyni, J.R., C.P. Beck, and W. Mountjoy, 1971, Nahcolite Analysis of Three Drill Cores from the Saline Facies of the Green River Formation in Northwest Colorado: USGS OFR.

4. Weeks, J.B., G.H. Leavesley, F.A. Welder, and G.J. Saulnier, Jr., 1974, Simulated Effects of Oil Shale Development of the Hydrology of Piceance Basin, Colorado: U.S. Geological Survey Professional Paper 908.

5. Coffin, D.L., F.A. Welder, and R.K. Glanzman, 1971, Geohydrology of the Piceance Creek Structural Basin, Between the White and Colorado Rivers, Northwestern Colorado: U.S. Geological Survey Hydrologic Investigation, Atlas: HA-370

6. East, J.H. Jr., and E.D. Gardner, 1964, Oil Shale Mining, Rifle, Colorado, 1944-56: Bulletin 611, U.S. Bureau of Mines.

7. Soil Conservation Service, 1960, Soil Classification, A Comprehensive System, 7th Approximation: USDA.

8. Fox, C.J., 1973, Soils of the Piceance Creek Basin: in Thorne Ecological Institute, An Environmental Reconnaissance of the Piceance Basin, Part 1, Phase I, Regional Oil Shale Study.

9. Marlatt, W.E., 1973, Climatology: in Environmental Setting of the Parachute Creek Valley: An Ecological Inventory, Thorne Ecological Institute for Colony Development Operation.

10. Cameron Engineers, 1975, A Technical and Economic Study of Candidate Underground Mining Systems for Deep, Thick Oil Shale Deposits, Phase I Report: USBM Contract Report S0241074

11. Morrison-Knudsen Company, 1975, Community Development Preliminary Report: Rio Blanco Oil Shale Project, Tract C-a.

12. Rio Blanco Oil Shale Project (RBOSP), 1975, Rangely, An Energy Development Alternative for Northwest Colorado.

13. Wengert, N., 1973, Oil Shale Country Fact Book: Garfield Mesa, Moffat, and Rio Blanco Counties, Colorado: Colony Development Operation, Parts I-III.

14. Oil Shale Regional Planning Commission, 1973, Health/Welfare/Migrant Problems; Mesa County, Garfield County, Rio Blanco County: Unpublished Report, Rifle, Colorado.

15. Colorado University, 1972, Colorado Population Trends: Business Research Division, v.1, n.4.

16. Spielman, C.O., 1976, Speech -- 5th Quarterly Meeting Government Administrators: RBOSP